DEPARTMENT OF THE ARMY
HEADQUARTERS, UNITED STATES ARMY 89TH REGIONAL SUPPORT COMMAND
2600 NORTH WOODLAWN STREET
WICHITA, KANSAS 67220-2799

JAN 2 ? 1998
SUPERFUND DIVISION

REPLY TO
ATTENTION OF

January 15, 1998

Engineering/Environmental

Mr. Robert Koke
Remedial Project Manager/Federal Facilities Section
U.S. Environmental Protection Agency, Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101

Dear Mr. Koke,

The U.S. Army 89th Regional Support Command (RSC), is requesting your assistance/clarification on a couple of items concerning two sites listed on the federal facilities hazardous waste sites docket. Per a conversation with Karla Ashberry, the two areas in question listed on the docket are, the St. Louis Ordnance Plant (SLOP) at 4300 Goodfellow Blvd., and the Hanley Area, at E. Natural Bridge, Goodfellow Blvd., St. Louis, MO.

The first item we are requesting is clarification on the boundaries of the above mentioned sites. In 1997, the 89th RSC acquired approximately 11 acres of property that was part of the former SLOP. In 1993, 14.7 acres of the area, once leased by Hanley Industries and historically known as the Hanley Area was transferred to the Department of Labor (DOL). This land was transferred from Fort Leonard Wood to DOL prior to the 89th RSC's acquisition of the remaining approximate 11 acres. Real estate transfer documents indicating the property transfers are enclosed for your review.

Secondly, we are requesting your determination on whether we will be required to conduct a preliminary assessment or if the enclosed environmental documentation and reports will suffice as the preliminary assessment.

Clarification on these matters will assist us in completing an Installation Action Plan and conduct any additional sampling needed and is appreciated. If there are any questions please contact Mr. Steven A. Lawson at (800)892-7266 ext. 449 or Maria Lehner at (913)782-7939.

John A. Fenili
Facility Management Officer
U.S. Army 89th Regional Support Command

Enclosures

30098842
Superfund

U S A T H A M A

U.S. Army Toxic and Hazardous Materials Agency

REMEDIAL INVESTIGATION/ FEASIBILITY STUDY

ST. LOUIS ORDNANCE PLANT INSTALLATION RESTORATION PROGRAM

Work Plan (Final)
Task Order 3
Contract Number DAAA15-88-D-0009

May 1989

ST. LOUIS ORDNANCE PLANT, HANLEY AREA
REMEDIAL INVESTIGATION/FEASIBILITY STUDY

WORK PLAN

ICF TECHNOLOGY INCORPORATED
9300 LEE HIGHWAY
FAIRFAX, VA 22031

JULY 1989

FINAL

U S A T H A M A

U.S. Army Toxic and Hazardous Materials Agency

REMEDIAL INVESTIGATION/ FEASIBILITY STUDY

ST. LOUIS ORDNANCE PLANT INSTALLATION RESTORATION PROGRAM

Work Plan (Final)
Task Order 3
Contract Number
DAAA15-88-D-0009

May 1989

TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

LIST OF EXHIBITS

LIST OF EXHIBITS
(continued)

aspects of the RI/FS are described in Section 9. The management plan is provided in Section 10, and describes the management structure for the project, including proposed personnel and duties, and management controls. Resumes of key personnel are presented in Appendix D. Finally, Section 11 describes the administration and reporting requirements for this project.

1.1 BACKGROUND

The following section presents information that is known regarding the St. Louis Ordnance Plant (SLOP) and more specifically, the area under investigation. This includes information on the site history, physical setting of the area, and a summary of potential environmental problem identified at the site as a result of previous investigations.

1.1.1 Site History and Characteristics

The St. Louis Ordnance Plant is located on the northwestern border of the city of St. Louis, Missouri, where it joins with St. Louis County (Exhibit 1-1). Most of the installation is located within the corporate limits of the city of St. Louis. The total area of the installation is 279.5 acres. Large portions of this acreage have previously been transferred by the Army to various federal and city government entities. The area formerly known as Hazardous/Chemical Area No. 2, consisting of approximately 28 acres, has to date not been transferred and remains under the ownership of Fort Leonard Wood (FLW). Approximately 13 acres of Hazardous/Chemical Area No. 2 are currently occupied by the Department of Labor (DOL) for the operation of the St. Louis Jobs Corps Training Center. The remaining 14.7 acres are known as the Hanley Area. It is this area of the SLOP that is the subject of the RI/FS study (Exhibit 1-2). Much of the following information on the history of SLOP operation was taken from "Survey of Hazardous/Chemical Area No. 2 of the Former St. Louis Ordnance Plant," US Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, June 1981.

Chronology of Operations - General

1941 The St. Louis Ordnance Plant (SLOP) was constructed between January of 1941 and May of 1942. Initial production of ammunition began as early as December of 1941. During World War II the facility was operated as a Government owned, contractor-operated (GOCO) plant for the production of small arms ammunition and components for 105 mm shells. Three contractors occupied the facility at this time engaging in the production of various ordnance.

1941-1957 Major Contractors

- The United States Cartridge Company (U.S. Cartridge), a subsidiary of Olin Industries, was engaged in the manufacture of small arms ammunition. U.S. Cartridge occupied Plants 1 and 2 (187 acres) as identified on the outlease map of SLOP shown in Exhibit 1-3. This company is reported to have produced 67 million rounds of ammunition (Ref 1--Battelle report, June 1981).

ST. LOUIS ORDNANCE PLANT, HANLEY AREA
REMEDIAL INVESTIGATION/FEASIBILITY STUDY

WORK PLAN
(TECHNICAL/MANAGEMENT PLANS)

1.0 INTRODUCTION

The United States Army Toxic and Hazardous Materials Agency (USATHAMA) is undertaking a Remedial Investigation/Feasibility Study (RI/FS) of portions of the St. Louis Ordnance Plant (SLOP). The area under investigation represents only the portion of the former ordnance plant known as the Hanley Area. The purpose of this RI/FS is to determine: if contamination resulting from past site operations exists; if present, whether contamination is migrating through the environment and impacting potential receptors (i.e., posing risks to human health and the environment); and the necessity for conducting remedial actions and the feasibility of such actions. In addition, the site investigation will provide the Army with data necessary to allow decisions to be made regarding the preparation of the property for remediation and subsequent excess and transfer. This RI/FS will be performed by ICF Technology, Inc., in accordance with CERCLA guidance.

This work plan summarizes existing data and background information, and defines the scope of the RI/FS activities. It is based on:

- Objectives and information presented in Delivery Order No. 0003 of Contract DAAA15-88-D-0009, Task Order No. 3, entitled "St. Louis Ordnance Plant Installation Restoration Program", and issued on March 28, 1989.

- Evaluation of existing data as discussed in Section 1.1;

- Conversations with representatives from USATHAMA, US Army Reserve and US Army Engineer Center Ft. Leonard Wood; and

- Results of a site visit that took place on April 11-12, 1989.

Section 1 of the work plan summarizes existing data; task objectives, and scope of the site investigation. Section 2 presents the field operations plan for the proposed hydrogeologic investigation and field sampling. Section 3 presents the plan for performing a risk assessment for the site. Section 4 summarizes the laboratory certification and chemical analysis required for this task. Section 5 summarizes the quality assurance and quality control program for the investigation, which is presented in detail in the Project Quality Control Plan in Appendix A. The implementation of USATHAMA's data management program is summarized in Section 6 and detailed in Appendix B - Data Management Plan. Section 7 presents an overview of the Health and Safety Plan which has been prepared to assure that field operations are conducted in a safe manner. The detailed Health and Safety Plan is presented in Appendix C, Accident Prevention Safety Program Plan. Section 8 describes the Community Relations Support anticipated for this RI/FS. Assessment and reporting

EXHIBIT 1-1

ST. LOUIS ORDNANCE PLANT AREA MAP

(From:USGS 7.5' Clayton Quadrangle)

SCALE 1:24 000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET

NATIONAL GEODETIC VERTICAL DATUM OF 1929

EXHIBIT 1-2

SITE INVESTIGATION AREA--SLOP

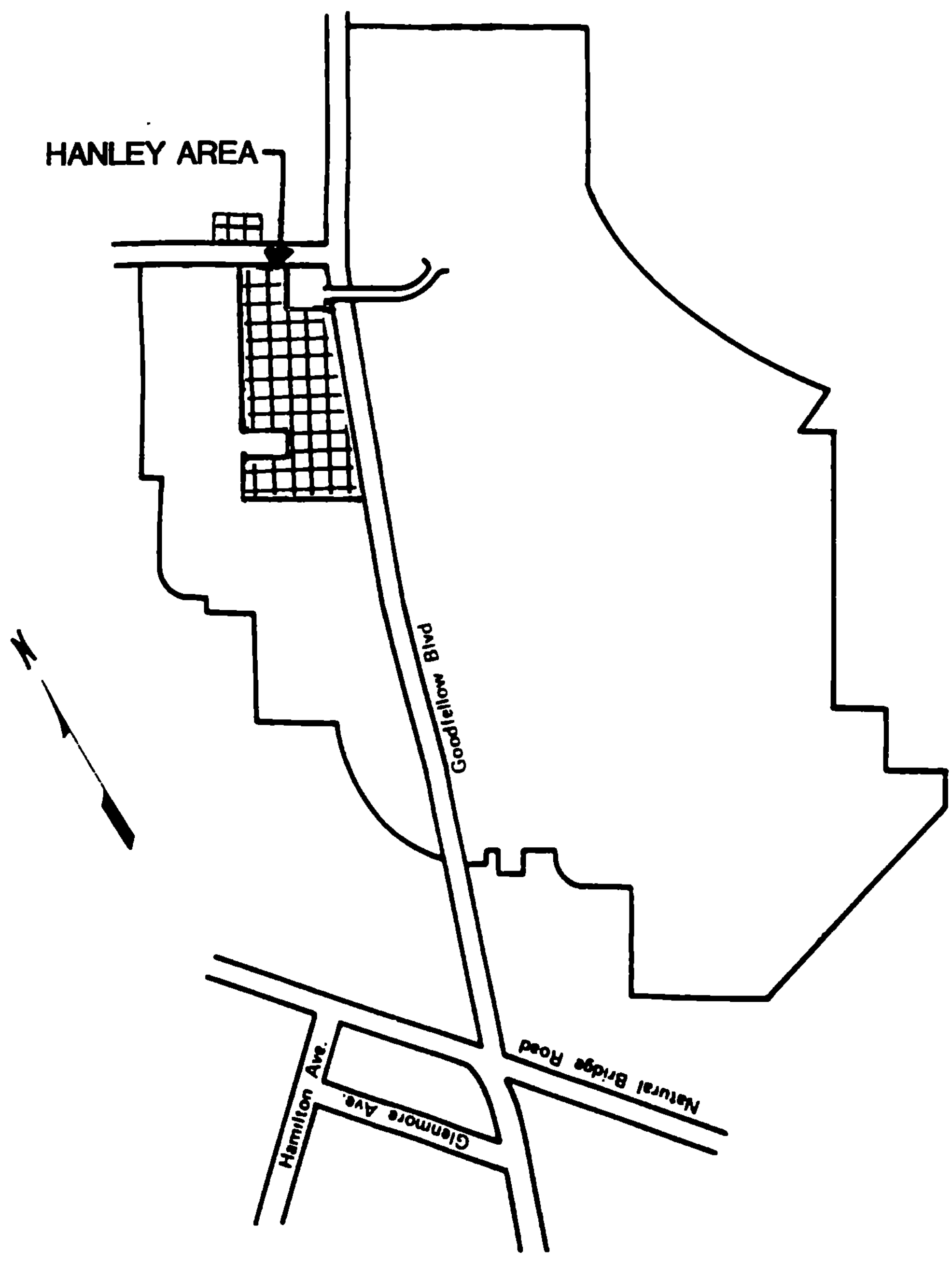
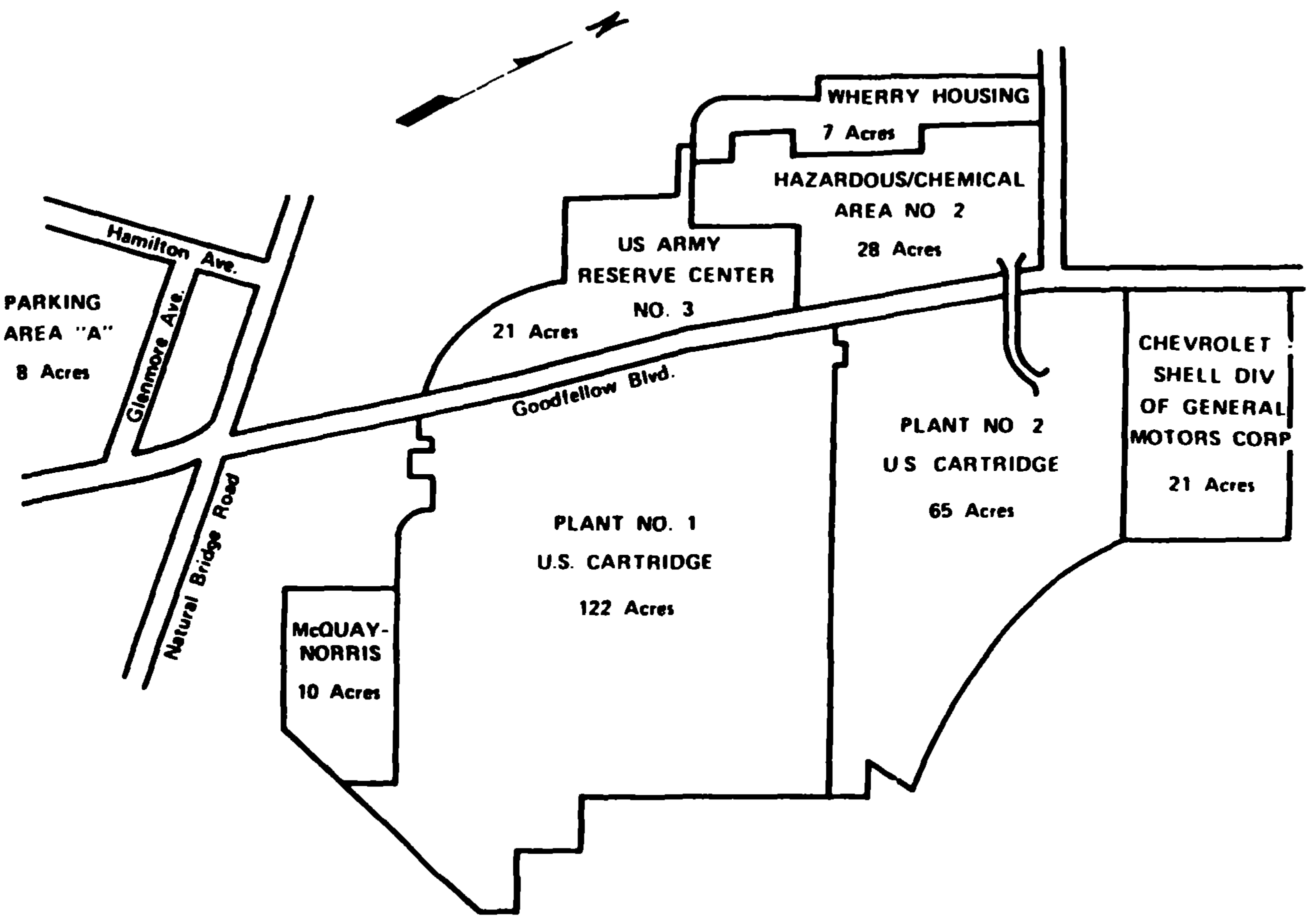


EXHIBIT 1-3

OUTLEASE MAP OF ST. LOUIS ORDNANCE PLANT



- The Mcquay-Norris Manufacturing Company was engaged in the manufacture of cores for small arms ammunition in a 10-acre area located to the extreme south of the installation, located south of interstate-70 on Goodfellow Boulevard near Natural Bridge Road (Exhibit 1-3). This company is reported to have produced 8 billion cores.

- The Chevrolet-Shell Division of General Motors Corporation operated a 21-acre plant for the manufacture of 105mm shells, located in the northeastern part of the installation (Exhibit 1-3). This area was operated as the St. Louis Army Ammunition Plant (SLAAP).

1945	In 1945, the SLOP was deactivated following the end of World War II. Decontamination procedures are reported to have been carried out at this time by the Army Corps of Engineers on all buildings having explosive contamination. No documentation of the decontamination procedures is known to exist, but many of the existing buildings at the SLOP bear markings of XXXXX indicating that they have been decontaminated and inspected after decontamination to verify their safety and absence of explosives contamination. With the exception of the powder wells that exist onsite, all of the buildings and magazines located in the area targeted for this RI/FS are so marked.
1945-1951	Following deactivation of the area, all property and buildings except the McQuay-Norris plant, were used as an administrative center for the Army Service Forces, and were operated as the St. Louis Administration Center. Installation buildings were used for maintaining and servicing records. Also during this period, the Wherry Housing Project, consisting of 120 apartments, was built. This housing area is located on the west side of Goodfellow Boulevard, just west of the study area (Exhibit 1-3).
1951-1957	In 1951, the SLOP was again placed in active status in response to escalation of the Korean conflict. Ordnance production of ammunition, cores and shells began again and was conducted by the three previous contractors in the same areas of the installation that were previously used. In 1954 the facilities used for the production of shells (Chevrolet-Shell Division) were placed on standby status. Small arms ammunition (U.S. Cartridge) and small arms ammunition cores production (McQuay-Norris) continued until 1957 when the SLOP was again placed in an inactive status.
1957-present	From 1957 to the present, very little information is available on the history and current operations of facilities located on the east side of Goodfellow Boulevard. It is known that for a short period of time between 1966 and 1969, SLAAP, the Chevrolet-Shell plant area, was reactivated for the production of projectiles. These areas are located outside the scope of

the site investigation, and have for the most part been excessed and transferred to a variety of federal and city government agencies, including the General Services Administration.

1976	The US Army Reserve established a new Reserve Center located south of, and adjacent to, the Hanley Area, on the west side of Goodfellow Blvd. This facility consists of an administrative building, a vehicle maintenance shop, and a large open area immediately adjacent to the Hanley Area that is currently used as a helicopter landing area.
Present	Other areas surrounding the study area have commercial, residential, and industrial uses.

Chronology of Operations - Hazardous/Chemical Area No. 2 (including Hanley Area)

1941-1945	It is unclear what operations were conducted during the 1941-45 period at the Hazardous/Chemical Area No. 2. Building 223A and B may have been used for tracer bullet manufacture. These buildings are located in the current DOL portion of former Hazardous/Chemical Area No. 2. Building 234 may have been used in the manufacture of primers, and is located on the south end of Hazardous/Chemical Area. No. 2. This building is located in an area south west of the site under investigation. Little information exits regarding specific activities that occurred during 1941-45 in the area targeted for the current site investigation. It is known that explosive mixing and storage occurred on the site during this period. Buildings that exist today on the site were present during the 1941-45 period and were probably built in 1942.
1945	SLOP was deactivated and all buildings having explosives contamination were reportedly decontaminated by the Army COE.
1945-1951	Many of the buildings were made available and the US Army Finance Center used various buildings for classrooms until 1951.
1951-1959	The buildings were rehabilitated for small arms ammunition manufacture in response to the Korean Conflict. Machinery was installed but production never commenced. After the Conflict, the machinery was removed and disposed of.
1959-1979	Hanley Industries Inc. leased 14.7 acres of the Hazardous/Chemical Area No. 2; this area has since become known as the Hanley Area and is shown in Exhibit 1-4. The remaining 13 acres or so of Hazardous/Chemical Area No. 2 were used to establish Goodfellow US Army Reserve Center (GUSARC) in the early 1960's (Exhibit 1-4). GUSARC was used for Army Reserve operations and training until 1977.

EXHIBIT 1-4

HANLEY AND GOODFELLOW US ARMY RESERVE CENTER AREAS OF FORMER HAZARDOUS/CHEMICAL AREA NO. 2 OF SLOP

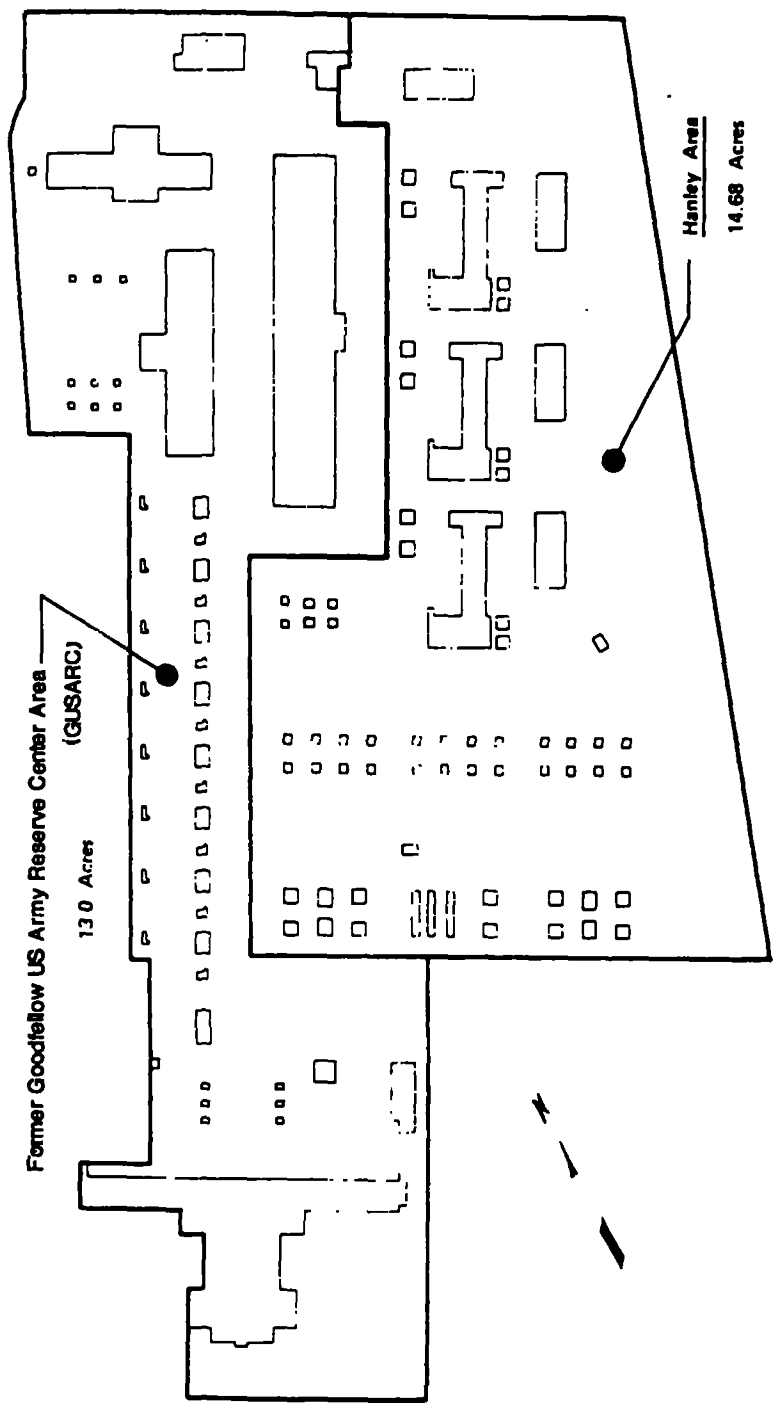


EXHIBIT 1-5

EXPLOSIVE TRAINS AND COMPONENTS THAT WERE DESIGNED BY HANLEY INDUSTRIES

Explosive bolts

Cord cutters

Bolt cutters

Battery activation cartridges

Cartridges to spin up a gyroscope

Balloon inflaters

Bellows and piston motors

Pellets of explosives

Bailer tube expansion charges

Unusual primary explosives

Spotting charges for warheads

Explosive detents

Indicators

Smoke and flash signals

Explosive or squib switches

Cartridges to uncage a gyroscope

Boosters

Pyrotechnic delay cartridges and detonators to open lap belts

Deploy parachutes

High altitude sounding grenades

1979-present In 1979 the Department of Labor identified the Hazardous/Chemical Area No. 2, both the GUSARC and Hanley Areas, as a potential site for placement of a Jobs Corps Center. In the early 1980's, the DOL began renovation and occupation of various buildings in the GUSARC area. Demolition of some buildings and construction of new facilities occurred as well. The DOL was directed to decontaminate those areas and structures previously found to be contaminated. It is unclear as to what decontamination procedures, if any, were followed by the DOL prior to or after the occupation of the GUSARC area.

Chronology of Operations - Hanley Area

1959-1979 Hanley industries used the area for research, development, manufacture, and testing of various explosives and did considerable work in the design of explosive trains and components. Exhibit 1-5 lists explosive trains and components designed by Hanley. Hanley Industries operated equipment required for the synthesis, receiving, drying, screening, mixing, loading, pressing, and testing of explosives. Additionally, explosives were loaded into various component parts for both military ordnance and non-ordnance items. See Exhibit 1-6 for a list of these items. Exhibit 1-7 depicts building locations within the study area.

Most of Hanley's buildings were used for loading detonators and primers and for explosive mixing. Explosives were dried in magazines by leaving cans of explosives exposed to the air. Hanley operated a lead azide reactor in one onsite magazine. Hanley is reported to have not used the existing sumps or powder wells located on the property. Summaries of the buildings and their uses are provided in Exhibits 1-8 and 1-9. This information is the only information available on the uses of individual buildings in the study area. Also, a list of compounds utilized by Hanley Industries is provided in Exhibit 1-10.

1979 Decontamination procedures were required to have been conducted by Hanley as part of the lease termination. The extent of decontamination and procedures that were followed were not well documented, but apparently consisted of washing down the walls in the buildings to a height of 8 feet above the floor. None of the magazines were washed down. Washdown water from the cleaning operation was discharged onto the ground outside the buildings.

1979-Present No operations have been conducted in the Hanley Area since the withdrawal by Hanley Industries. The area is currently in an inactive and degrading state and is fenced off to prevent public access.

EXHIBIT 1-7

SITE MAP--ST. LOUIS ORDNANCE PLANT RI/FS

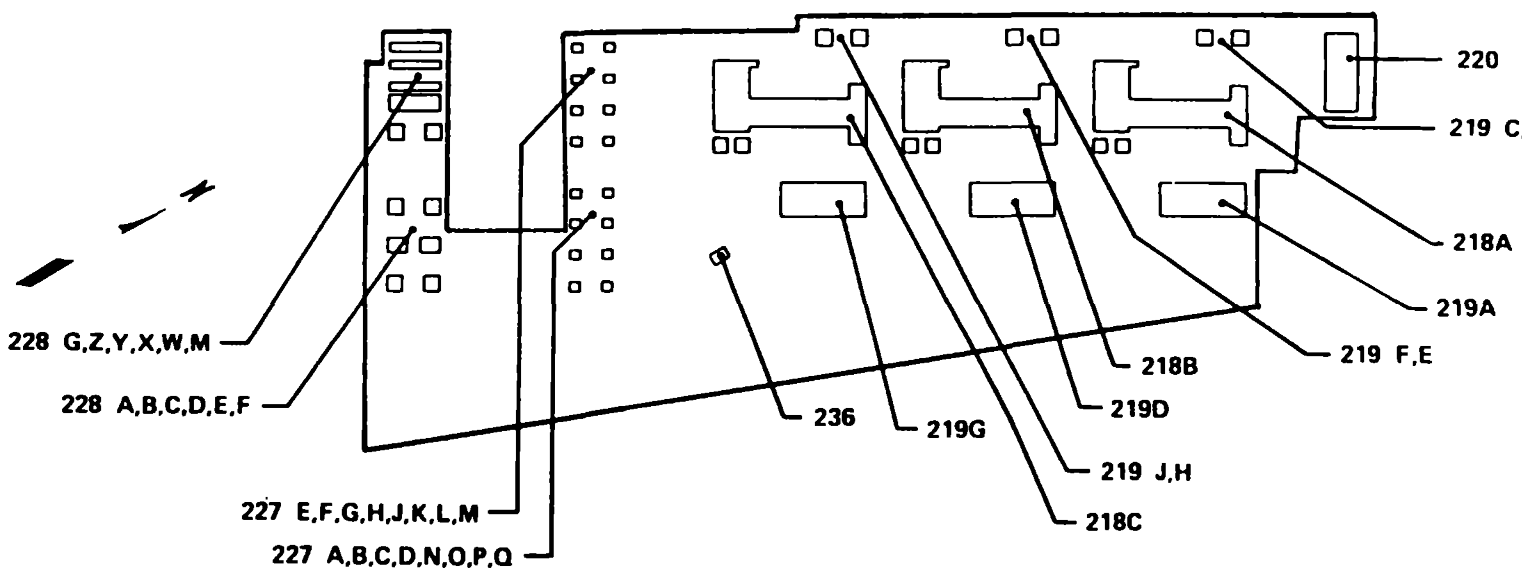


EXHIBIT 1-6

EXPLOSIVE COMPONENTS LOADED FOR THE MILITARY AND NASA BY HANLEY INDUSTRIES

Delay cartridges

Leads

Detonators

Primers (electric and delay)

Squibs

Explosive Bolts

Activators

Bomb Initiators

Spotting charges

Boosters

EXHIBIT 1-10

HANLEY INDUSTRIES

COMPOUNDS UTILIZED

Lead Styphnate

Tetryl (2,4,6-Trinitrophenylmethylnitramine)

RDX

NOL 130 (Primer mix having the following composition: 20% lead azide, 15% antimony sulfide, 20% barium nitrate, 40% lead styphnate, and 5% tetracene.)

A180 (Ignition mix)

Black Powder

HMX (Cyclotetramethylenetetranitramine)

NOL 60 (Primer mix having the following composition: 10% antimony sulfide, 25% barium nitrate, 60% lead styphnate, and 5% tetracene.)

PETN (Pentaerythrite Tetranitrate)

Tetracene

Silver azide

Smokeless powder

Trinitroresorcinol

Diazodinitrophenol

Delay powder (dependent on the composition used, may contain the following compounds: barium chromate, zirconium powder, nickel powder, potassium perchlorate, red lead, silicon powder, lead chromate, and manganese powder.)

Tracer mixes (dependent on the composition use, may contain the following compounds: strontium peroxide, magnesium powder, barium peroxide, strontium nitrate, strontium oxalate, magnesium carbonate, and aluminum powder.)

Lead nitrate

Sodium azide

Future — Future plans for the study area include renovation and use of existing buildings (Buildings 219G, D, and A) by the US Army Reserve Center. It is ICF's understanding that the Army Reserve will repair and renovate these buildings and use them as warehouse space. Army personnel will only visit these buildings on an infrequent basis. It is also understood that the Army Reserve intends to maintain and control the remaining portion of the Hanley Area. Any other future use of this area would likely involve demolition and removal of buildings (other than the warehouses).

Site Description. As a result of the site visit conducted at the Hanley Area on April 11 and 12, a site map has been developed that more accurately depicts the boundaries of the study area for this RI/FS. A simplified version of the site map is presented in Exhibit 1-7. A more detailed site map is presented in Pocket A at the end of this document. The study area is defined by a series of security fences and bunker walls that form a perimeter barrier around the site. In addition, Building 220 is included in the study area (see detailed site map, Pocket A). The site map shows the building, magazine, and bunker numbers for structures in the Hanley Area. It also shows the locations of powder wells that were used to collect wash water from the testing/ production buildings.

The three large buildings present on the Hanley Area, 218 A, B, and C, are currently in poor condition, having been stripped of usable equipment and material. The warehouses, numbered 219 A, D, and G, are in a similar degraded condition. The concrete bunkers are in good condition, however, the buildings within them are in a poor condition. Utility tunnels that run under the Hanley Area and other portions of the SLOP are intact and in good condition. One tunnel has been blocked off at the western border with the DOL area to prevent underground access to the Hanley Area from the DOL site. The tunnel system was found to be open where it extends from SLOP to an aboveground masonry access structure located on the eastside of Goodfellow Boulevard.

A survey of the Hanley Area conducted in 1980 showed heavy metal residues to be present on the interior surfaces of all buildings and in some powder wells and sewer pipes. Additionally, explosive residues were found on the interiors of several buildings and magazines and in the water of several powder wells. See Section 1.1.3, Previous Investigation, for more information.

1.1.2 Physical Setting

The St. Louis Ordnance Plant is located on the western edge of the city limits of St. Louis, Missouri. The facility lies approximately three miles west of the Mississippi River, and 0.25 miles south of the intersection of Interstate 70 and Goodfellow Boulevard. SLOP lies on the boundary between the west side of the City of St. Louis and the east side of St. Louis County (Exhibit 1-1).

The study area, referred to as the Hanley Area, comprises 14.68 acres and is located within the 28-acre Hazardous Chemical Area No. 2. The Hanley Area is situated on a broad terrace where the elevation is approximately 550 feet above sea level. Surface runoff from the Hanley Area flows eastward

EXHIBIT 1-8

HANLEY INDUSTRIES

BUILDINGS/MAGAZINES IN WHICH LOADING AND MIXING OF

EXPLOSIVES WERE CONDUCTED

Bldg	Room
218A	102, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 117, 121, 123. Delay powder loaded in basement under Room 105.
218B	110, 113, 115, 119, 123, 125, 127, 128-1, 128-2, 128-3, 128-4, 132
218C	104
219A	Loading of smokeless powder throughout
220	All rooms except basement

EXHIBIT 1-9

HANLEY INDUSTRIES

BUILDING USAGE

OTHER THAN FOR LOADING AND MIXING OF EXPLOSIVES

Bldg	Area	Usage
218A	All rooms not listed in Exhibit 1-7	Non-explosive storage
218B	Basement	Empty as non-explosive storage
218C	Basement	Burning of explosive contaminated rags
219A		Administrative
219D		Never used
219E		Lead azide production
219G		One time loading of explosives for disposal during cleanup operations
219B,C,F,H,J		Drying of explosives
All other magazines*		Storage of explosives in sealed containers

*Fencing arrangements in the 228 area reportedly precluded both beneficial and non-beneficial use of magazines 228A, B, C, D, G, N, O, and P by Hanley Industries. The Goodfellow US Army Reserve Center reportedly used these facilities intermittently for storage of equipment.

toward the Mississippi River. The gradient between the Mississippi River to the east and SLOP is approximately 150 feet.

1.1.2.1 Site Physiography

St. Louis County is located on the northwestern flank of the Ozark Plateau in the Dissected Till Plains Physiographic Province (Exhibit 1-11). Due to its stratigraphic position, the St. Louis area has been a receiving basin for sediments for most of its geologic history. Hunt (1974) characterizes the Ozark Plateau as a broad upwarp exposing early Paleozoic formations. Miller (1974) describes the Dissected Till Plain as a gently undulating surface with altitudes ranging from 500 to 700 feet. The area was glaciated twice during the Pleistocene, although till deposits are relatively thin, and typical morainal topography of glaciated surfaces is lacking in the study area.

1.1.2.2 Bedrock Geology

The bedrock geology in St. Louis County consists of essentially flat-lying sedimentary rocks, mostly limestone and dolomite which were deposited in shallow epicontinental seas. The regional structure of the rocks in the area is controlled by the forces that produced the Ozark uplift, the apex of which forms the core of the St. Francois Mountains to the southwest (Howe, 1961). In the St. Louis area, the structure is one of a monocline, gently dipping to the northeast at an average rate of 55 feet per mile (Gleason, 1935).

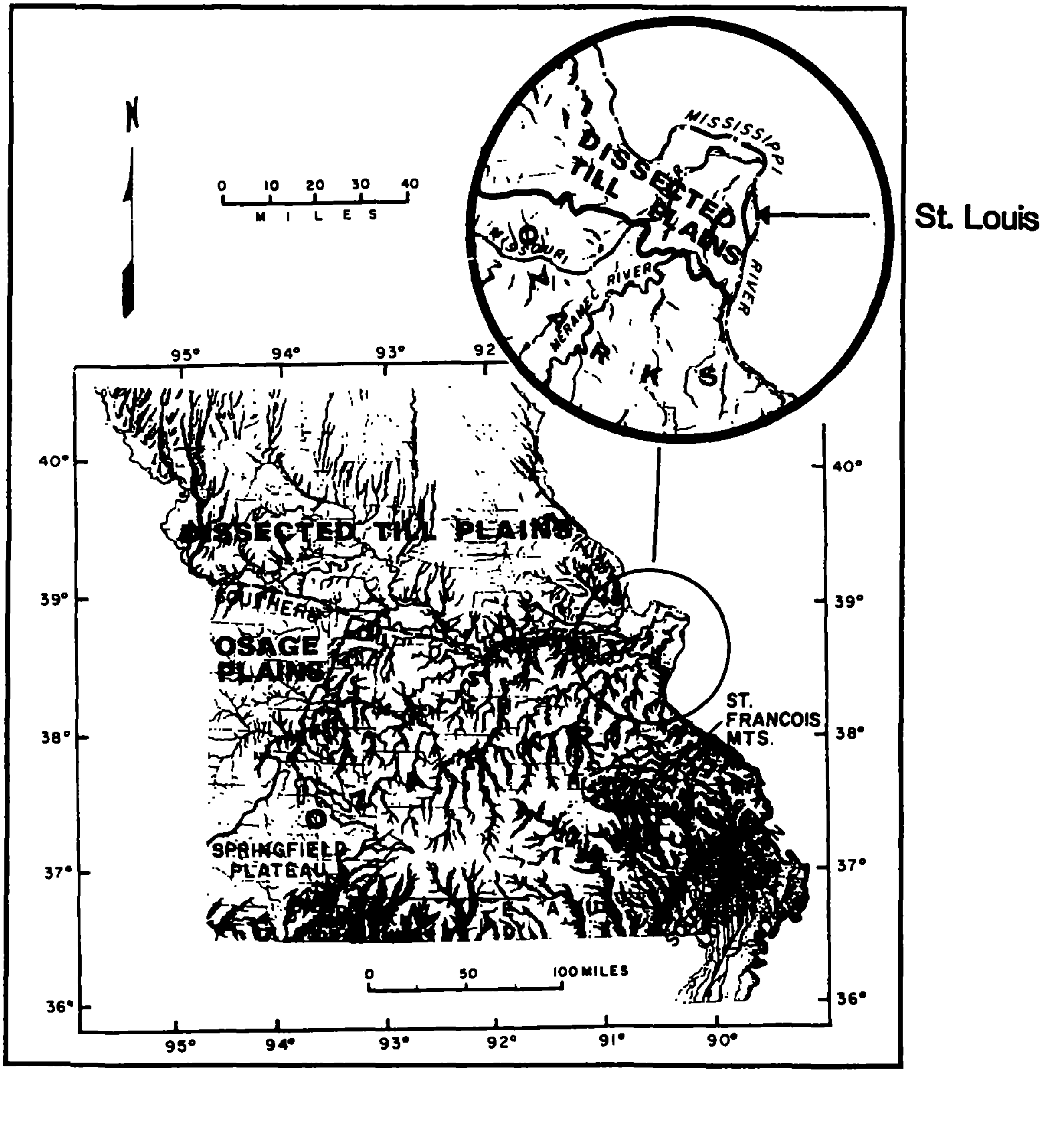
The structural attitude of the beds is a result of the compressional, tensional, and uplifting forces that have displaced and altered the beds from their original depositional positions (Miller, 1974). The combination of these forces have altered the beds so that presently a series of faults and fractures exist throughout the region. Locally, a number of faults are present both to the east and to the west of the Hanley Area of SLOP. Exhibit 1-12 illustrates the approximate location of these faults and structural features.

The geologic formations in St. Louis County range in age from Ordovician (430 million years before present (mybp)) to middle Pennsylvanian (300 mybp). The strata beneath the Hanley Area are early Pennsylvanian age rocks of the Marmaton and Cherokee Groups. Exhibit 1-13 presents a generalized stratigraphic column for St. Louis County, Missouri. These strata consist of mostly shale, but also contain thin, and not laterally continuous layers of clay, limestone, sandstone, and coal. Compared to the Cherokee group below, the Marmaton contains more limestone units which are thicker and more persistent (Howe, 1961). The Pennsylvanian units in the vicinity of SLOP have a thickness of less than 100 feet.

Mississippian age rock of the St. Louis and St. Genevieve Formations lie unconformably beneath Pennsylvanian strata. The St. Louis formation is characterized as a gray lithographic to finely crystalline, medium to massively bedded limestone which is more than 100 feet thick (Howe, 1961). Thin shale beds are common, and in places the St. Louis formation is dolomitic. Howe (1961) describes the St. Genevieve formation as white,

EXHIBIT 1-11

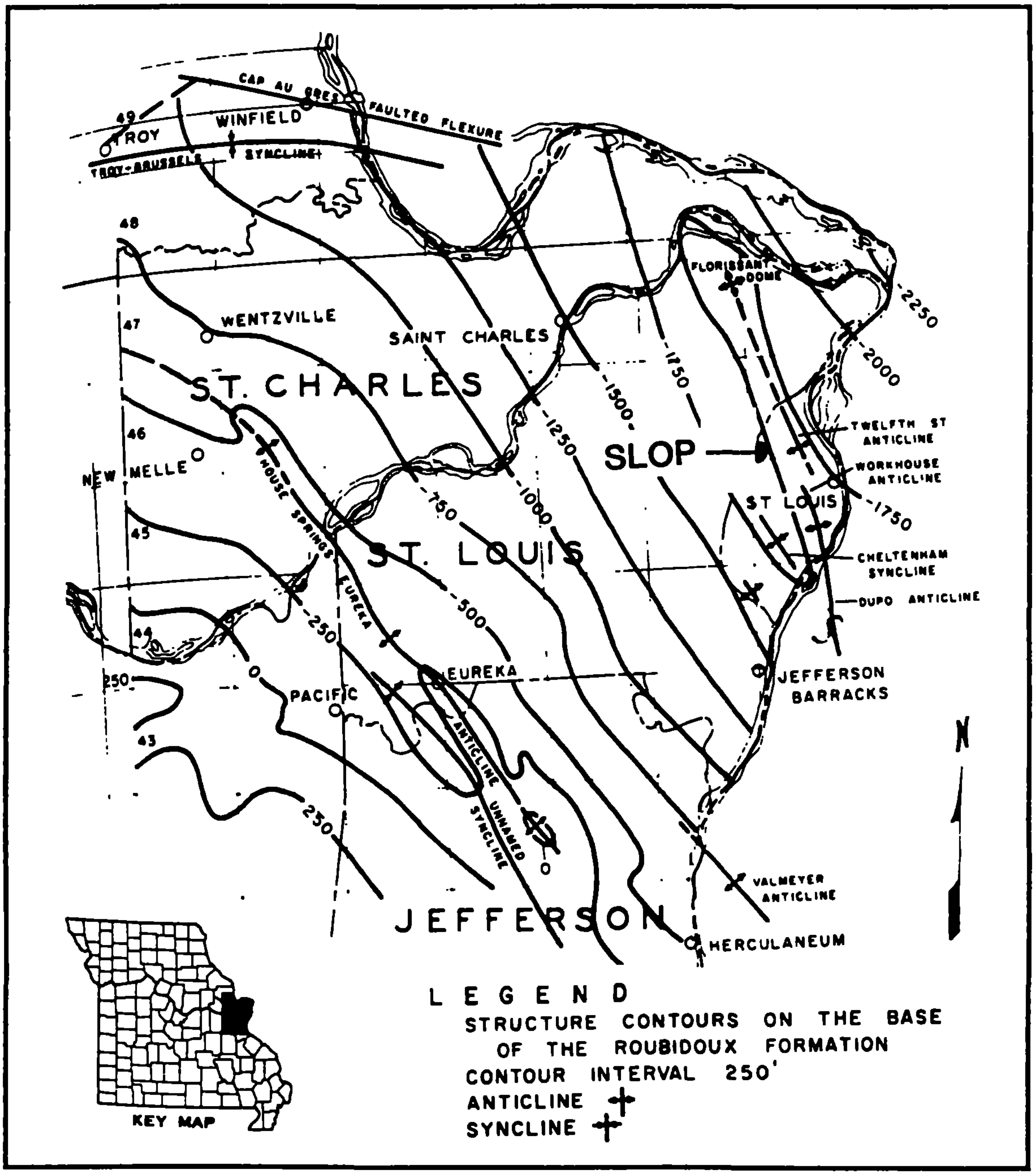
PHYSIOGRAPHY OF STUDY AREA



From: Miller, D.E., et al., 1974, Water Resources of the St. Louis Area, Missouri: Missouri Geological Survey and Water Resources, WR. 30.

EXHIBIT 1-12

GEOLOGIC FEATURES OF ST. LOUIS COUNTY AND VICINITY



From: Martin, J.A., and Wells, J.S., 1966, Guidebook to Middle Ordovician and Mississippian Strata, St. Louis and St. Charles Counties, Missouri, 1966 Annual Meeting, American Association of Petroleum Geologists, Report of Investigation, No. 34.

EXHIBIT 1-13

GENERALIZED STRATIGRAPHIC COLUMN FOR ST. LOUIS COUNTY, MISSOURI

System	Series	Group	Formation	Aquifer group	Thickness (feet)	Dominant lithology	Water-bearing character
Quaternary	Holocene		Alluvium[1]		0-150	Sand, gravel, silt, and clay.	Some wells yield more than 2,000 gpm.
	Pleistocene		Loess		0-110	Silt	
			Glacial till		0-55	Pebbly clay and silt.	Essentially not water yielding
Pennsylvanian	Missourian	Pleasanton	Undifferentiated		0-75	Shales, siltstones, "dirty" sandstones, coal beds and thin limestone beds.	Generally yields very small quantities of water to wells. Yields range from 0-10 gpm.
	Desmoinesian	Marmaton	Undifferentiated		0-90		
		Cherokee	Undifferentiated		0-200		
	Atokan		Undifferentiated				
Mississippian	Meramecian		St. Genevieve Formation		0-160	Argillaceous to arenaceous limestone	
			St. Louis Limestone		0-180		
			Salem Formation		0-180		
			Warsaw Formation		0-110		
	Osagean		Burlington-Keokuk Limestone	1	0-240	Cherty limestone	
			Fern Glen Formation		0-105	Red limestone and shale	Yields small to moderate quantities of water to wells. Yields range from 5 to 50 gpm. Higher yields are reported for this interval locally.
	Kinderhookian	Chouteau	Undifferentiated		0-122	Limestone, dolomitic limestone, shale, and siltstone.	
Devonian	Upper	Sulphur Springs	Bushberg Sandstone		0-60	Limestone and sandstone.	
			Glen Park Limestone				
			Grassy Creek Shale		0-50	Fissile, carbonaceous shale.	
Silurian			Undifferentiated		0-200	Cherty limestone.	
Ordovician	Cincinnatian		Maquoketa Shale		0-163	Silty, calcareous or dolomitic shale.	Probably constitutes a confining influence on water movement.
			Cape Limestone		0-5	Argillaceous limestone.	
	Champlainian		Kimmswick Formation		0-165	Massive limestone	
			Decorah Formation		0-50	Shale with interbedded limestone.	Yields small to moderate quantities of water to wells. Yields range from 3 to 50 gpm. Decorah Formation probably acts as a confining bed locally.
			Plattin Formation	2	0-240	Finely crystalline limestone.	
			Rock Levee Formation		0-93	Dolomite and limestone, some shale.	
			Joachim Dolomite		0-135	Primarily argillaceous dolomite.	
			St. Peter Sandstone	3	0-160	Silty sandstone, cherty limestone grading upward into quartzose sandstone.	Yields moderate quantities of water to wells. Yields range from 10-140 gpm.
			Everton Formation		0-130		
	Canadian		Powell Dolomite		0-150	Sandy and cherty dolomites and sandstone.	Yields small to large quantities of water to wells. Yields range from 10 to 300 gpm. Upper part of aquifer group yields only small amounts of water to wells.
			Cotter Dolomite		0-320		
			Jefferson City Dolomite	4	0-225		
			Roubidoux Formation		0-177		
			Gasconade Dolomite Gunter Sandstone Member		0-280		
Cambrian	Upper		Eminence Dolomite		0-172	Cherty dolomites, siltstones, sandstone, and shale.	Yields moderate to large quantities of water to wells. Yields range from 10 to 400 gpm.
			Potosi Dolomite		0-325		
		Elvins	Derby-Doerun Dolomite	5	0-165		
			Davis Formation		0-150		
			Bonneterre Formation		245-385		
			Lamotte Sandstone		235+		
Precambrian						Igneous and metamorphic rocks.	Does not yield water to wells in this area.

1/ Basal part may be of Pleistocene age.

NOTE: Stratigraphic nomenclature may not necessarily be that of the U.S. Geological Survey.

From: Miller, D.E., et al., 1974, Water Resources of the St. Louis Area, Missouri: Missouri Geological Survey and Water Resources, WR. 30.

EXHIBIT 1-14

GEOLOGIC MAP OF THE STUDY AREA

KEY

Pp - Pleasanton Gp.
Pm - Marmaton Gp.
Pc - Cherokee Gp.

SCALE 1:24 000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET

From: State of Missouri, Geological Survey and Water Resources (Preliminary, not field checked).

massively bedded, sandy, clastic limestone. It is generally coarsely crystalline and oolitic and contains a few beds of finely crystalline limestone. Additionally, the St. Genevieve may in places contain lenses of chert, and sandstone. In St. Louis County, the formation is approximately 30 feet thick. There is a disconformable contact between the St. Louis and the overlying St. Genevieve, with a basal conglomerate present in places.

Based on the literature review and information gathered from borings in the vicinity of the SLOP facility, it is expected that bedrock will be encountered at a depth of approximately 20-30 feet beneath the ground surface. Bedrock at SLOP lies beneath unconsolidated sediments of the Harvester Complex which is characteristically moist, but lacking significant amounts of water. The bedrock is composed of Pennsylvanian age shales and clayey shales of Cherokee Group. These units are expected to be approximately 70 feet thick. Exhibit 1-14 presents a geologic map of the study area.

Almost all bedrock formations in the St. Louis region have been covered by laterally extensive deposits of windblown silt (loess) derived from the floodplain of the Missouri River during the Pleistocene glaciation. Vertically the loess deposits are relatively thin in the area.

1.1.2.3 Climate

The climate in St. Louis County is characteristic of temperate continental, with warm-to-hot summers and cool winters. The heaviest rains occur in spring and early summer, when moist air from the Gulf of Mexico interacts with drier continental air (Soil Conservation Service, 1979).

The average daily temperature for the St. Louis area is about 55 degrees Fahrenheit (F). The average winter temperature is about 33 degrees F, and about 77 degrees F in the summer. The growing season for most crops extends from April to September.

Total annual precipitation is 33.8 inches, with the greatest amount falling in June. Average seasonal snowfall for the region is 18 inches, March being the month with the greatest accumulation. The prevailing wind is from the south. Wind speed is highest in March, averaging 12 miles per hour.

1.1.2.4 Soils

The soil matrix at the Hanley Area of SLOP has been characterized and mapped by the Soil Conservation Service as Urban Land, upland, with 0 to 5 percent slopes. The classification is described by the SCS as surfaces composed of greater than 85 percent manmade, impervious materials. Typically, these soils have been extensively reworked and reshaped. Once undulating surfaces have been leveled and benched during construction activities. Detailed on-site investigation and classification of the soils in the Hanley Area has not been performed by the SCS due to the inaccessibility of the soils.

Immediately adjacent to the contour boundaries of the Urban Land map unit, in all directions, lies the Urban Land-Harvester Complex. Harvester soils consist of deep, moderately drained soils on uplands. These soils were formed in 12 to 40 inches of reworked loess fill material over truncated or buried loess soils. Permeability is moderately slow.

Typically, the surface layer of the Harvester soil is brown silt loam about 4 inches thick. The next layer, to a depth of approximately 37 inches consists of multicolored silt loam material that contains fragments of bricks, glass, cinders, and other manmade materials. Below the reworked fill material, to a depth of approximately 60 inches is the lower part of a buried soil. It is a dark yellowish brown, mottled, firm, silty, clay, loam. In heavily reworked areas, most or all of the original soil has been removed.

1.1.2.5 Hydrogeology

Groundwater in the vicinity of the Hanley Area occurs primarily in the fractures, solution cavities, and along bedding planes of the Mississippian limestone strata that lie beneath the younger Pennsylvanian rocks at SLOP. Generally, the Pennsylvanian shales of the area are relatively impermeable, and yield very little water. The exception being the Cherokee Formation which may contain small amounts of groundwater in the thin sandy shales and sandstone units that comprise the formation (Gleason, 1935).

It is expected that groundwater at the Hanley Area will be encountered during drilling operations at a depth of approximately 80 to 120 feet beneath the surface, at the base of the Pennsylvanian strata. Additionally, it is likely that one or more perched systems exist within the Pennsylvanian formations, although these systems are expected to be to be quite thin and very poor producers. Groundwater flow rates in the St. Louis area (Mississippian rock units) are classified as low producers with an average rate of less than 50 gallons per minute (Exhibit 1-15).

1.1.3 <u>Previous Investigation</u>

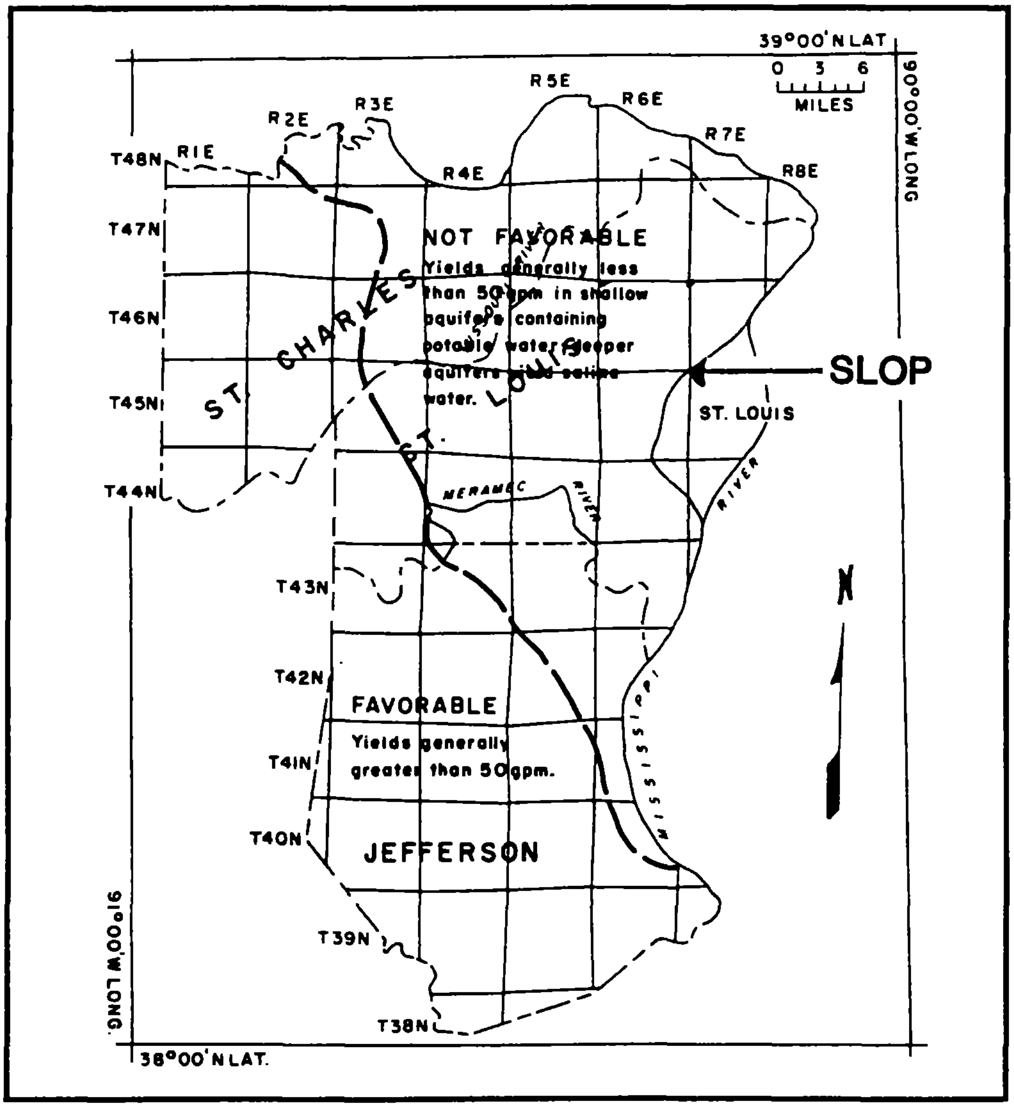
There has been one previous site investigation conducted at the Hanley Area. This was done by Battelle Columbus Laboratories for USATHAMA in 1979-80 and encompassed both the Hanley Area and the former GUSARC (current Job Corp Training Center). Battelle's survey efforts included a historical investigation, a site survey and visual inspection, and selected field sampling for heavy metals and explosives contamination. A final report on this investigation was provided to USATHAMA in June 1981.

The investigation was requested of USATHAMA when in 1979 the Department of Labor identified the Hazardous/Chemical Area No. 2 as a potential site for placement of the Jobs Corps Center. The Battelle investigation was performed to ascertain the status of contamination and the suitability of the property for release to the Department of Labor. The survey was conducted in two phases. The GUSARC area survey was conducted from January through May of 1979 and the Hanley Area survey was conducted from August to November of 1980.

The historical investigation consisted of a records search and interviews with current and former employees. The records review included searching the National Personnel Records Center, St. Louis, MO; Industrial

EXHIBIT 1-15

YIELDS FROM BEDROCK AQUIFERS



From: Miller, D.E., et al., 1974, Water Resources of the St. Louis Area, Missouri: Missouri Geological Survey and Water Resources, WR. 30.

EXHIBIT 1-16

INTERVIEW FINDINGS--HANLEY AREA

Building/Magazine	Findings
218A, B, and C	Primers and tracer mixing (1941-45), Loading and mixing of explosives (1959-79)
219A, D, and G	Primer and tracer mixing (1941-45); Loading of smokeless powder (219A) and administrative space (219D and G) from 1959-79
219B, F, and J	Open air drying of explosives (219B) and burning (219F and J) of explosives (1959-79)
219C and H	1941-45 use unknown; Open air drying of explosives (1959-79)
219E	1941-45 use unknown; Lead azide production (1959-79)
220	Used for administrative space (1941-45); Explosive laboratory (1959-79)
226 Series	Explosive mixing operations (1941-45); Storage of explosives in sealed containers (1959-79)
227 Series	Explosive mixing operations (1941-45); Storage of explosives in sealed containers (1959-79)
227T	Administrative space (1941-45); Abandoned 1945-79
228 Series	Powder storage (1941-45); Abandoned form 1945-79
229 Series	1941-45 use unknown; Storage of explosive end items (1959-79)
236	Appears to be garage (1941-45); Not used 1945-79.

Social Division of the National Archives, Washington, DC; Washington National Records Center, Suitland, MD; Offices of the Kansas City District Corps of Engineers, Kansas City, MO; and the Historical Office of the Army Armament Readiness Command, Rock Island, IL. Documents specific to building and magazine usage and decontamination were not located.

Information gained from Hanley employees and the records review regarding site operations in the Hanley Area are summarized in Exhibit 1-16. (Also refer to Exhibit 1-7 for the map showing the locations of the buildings and related structures.) Hanley reportedly did not use the powder wells, but did use some of the on-site magazines for the storage of explosives and other material. Hanley used other buildings for munitions production activities. All explosive wastes generated by Hanley were reported to have been transported to Ft. Leonard Wood for disposal (Colvin et. al., 1981). A records search will be conducted at Ft. Leonard Wood to confirm that indeed this was the case. Additionally, aerial photographs (if available) will be assessed to determine if there is any indication of past waste disposal sites on or adjacent to the Hanley Area.

Sampling and analysis of the Hanley Area was initiated by Battelle in August 1980, shortly after decontamination procedures were accomplished by Hanley personnel when they vacated the premise. Efforts in the Hanley Area included the sampling of seven buildings, 54 magazines, 28 powder wells, and five sewer locations. Samples were analyzed for heavy metal and explosive residues. Spot sprays were used to target swab samples for explosives analysis. At least four surface areas in each of the buildings and magazines were wiped for metals analysis. These samples were analyzed for lead, silver, nickel, mercury, chromium, and cadmium.

Results of the Hanley Area sampling found heavy metal residues to be present on all building and magazine interior surfaces and in the discharge of the sewers. Concentrations of chromium ranged from 26 to 515 ug/square meter. Lead concentrations ranged from 800 to 27,200 ug/square meter. Concentrations of silver, nickel, mercury, and cadmium ranged from below the analytical detection levels to 24, 147, 32, and 102 ug/square meter, respectively. Silver, mercury, and chromium were below the detection limits in all sewer samples. Lead concentrations in sewer samples ranged from below the detection limit to 230 parts per billion (ppb) and nickel concentrations ranged from below the detection limit to 115 ppb. These results were believed to coincide with the historical building usage (e.g.,primer and tracer mixing are operations involving the use of metal-based compounds). The highest concentration of all heavy metals analyzed for in the survey was found in magazine 219E. Glazed building tile inside this structure had been painted, and Hanley Industries operated their lead azide reactor inside this magazine. Area locations of metals contamination found to be above detection limits are depicted in Exhibit 1-17.

Several building/magazines exhibited contamination from explosive residues. Buildings/magazines in which positive results were obtained from spot spraying and were verified by laboratory analysis were 218A, 218B, 218C, 219C, 219H, 220, 227A, 227B, 227J, 227M, 227O, 228C, and 228F. Explosive compounds were not detected in any of the powder well samples except those receiving effluent from buildings 218A and 218B. The composite samples from these powder wells' contained 4.0 and 4.6 ppb of tetryl, respectively. None of the sewer samples exhibited concentrations of explosives above detection limits. These results were also believed to coincide with historical building usage. Area locations of explosives contamination found to be above detection limits for the site are illustrated in Exhibit 1-18.

The visual inspection conducted by Battelle of the Hanley Area revealed the presence of a few detonators that have since been removed. Inspection of the buildings in the Hanley Area indicated that in several cases interior building walls were constructed of hollow tile in which explosive residues may have accumulated.

The results of the survey indicated that areas of potential contamination include all buildings, powder wells, sewers, floor drains, and any structures where munitions production, packing, or storage occurred. Floor drains and powder wells discharged to the municipal sewer which at one time could have discharged to the Mississippi River before its current destination: a municipal sewage treatment plant.

The investigative effort conducted at the GUSARC area also entailed sampling of the interior surfaces of buildings (total of 41), bunkers (7), and multiple-chamber powder sumps (9) for heavy metals and explosives contamination. Swipe samples, sludge, dust, and water samples were collected. Heavy metals residues were found to be present on the interior walls of most of the GUSARC buildings/bunkers. Contamination from explosives was found in the floor drains of several buildings.

1.2 TASK OBJECTIVES

The objective of this task is to conduct a Remedial Investigation/ Feasibility Study (RI/FS) of the Hanley Area which is a portion of the St. Louis Ordnance Station (SLOP). Work accomplished under this task will determine whether: contamination exists, whether contamination is migrating through the environment, and whether it is impacting potential receptors. The investigation will determine the necessity for remedial actions and the feasibility of these actions. In addition, work performed under this task will assist the Army in making an informed decision regarding remediation and subsequent excess and transfer of the property.

1.3 SCOPE OF THE TASK

The work plan for this task encompasses many related activities within the study area. These include:

- Performing a surface soils investigation to assess near-surface soil contamination from explosives, heavy metals, and other contaminants as appropriate. The presence of some chemical compounds will be assessed by analyzing for indicator chemicals of these compounds (e.g., mixers and powders will be assessed by analyzing for indicator chemicals of these compounds, such as lead, aluminum, barium, and magnesium). A similar approach will be applied to the analysis of liquid samples. Approximately 41 soil samples will be collected for analysis.

EXHIBIT 1-17

HANLEY AREA FACILITIES CONTAMINATED WITH HEAVY METAL RESIDUES

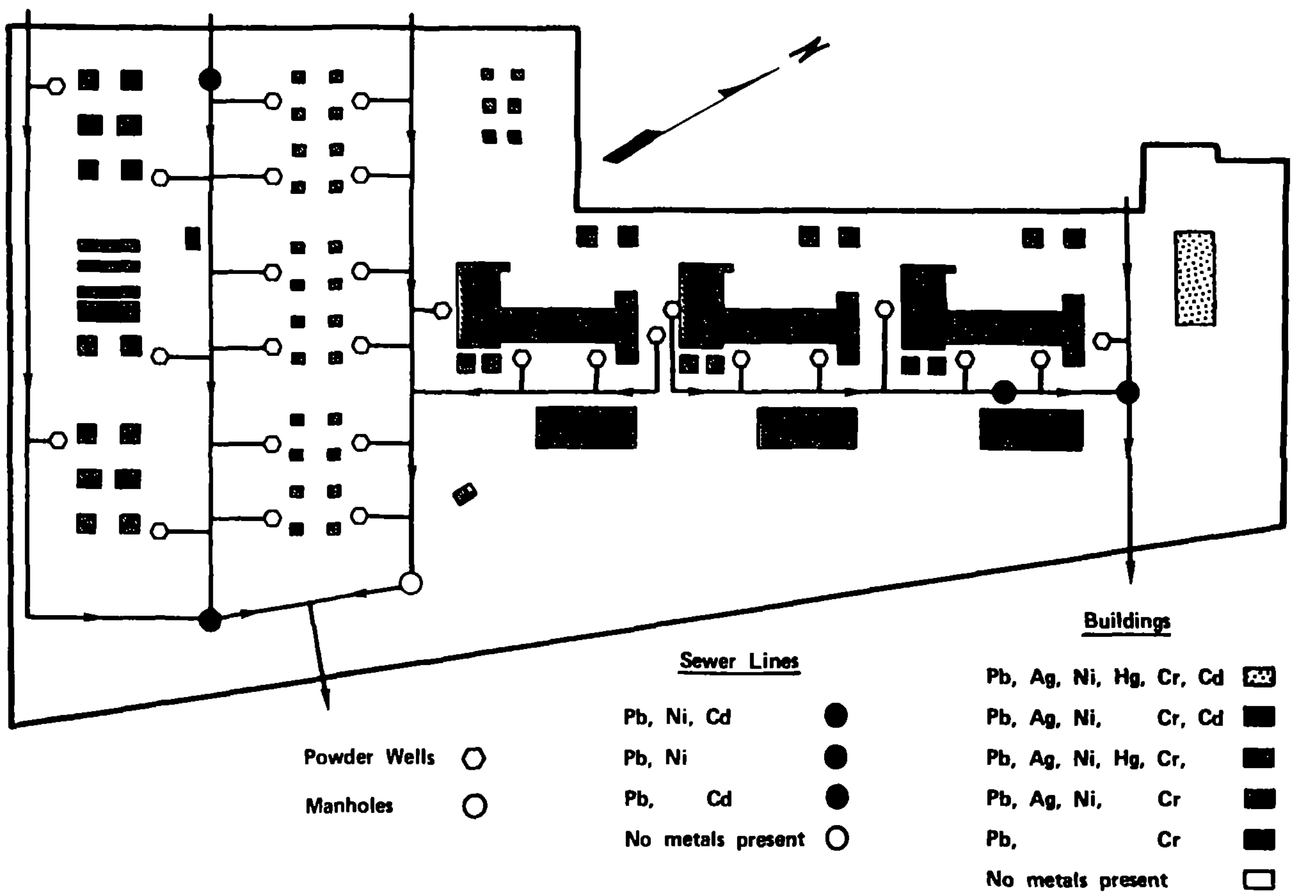
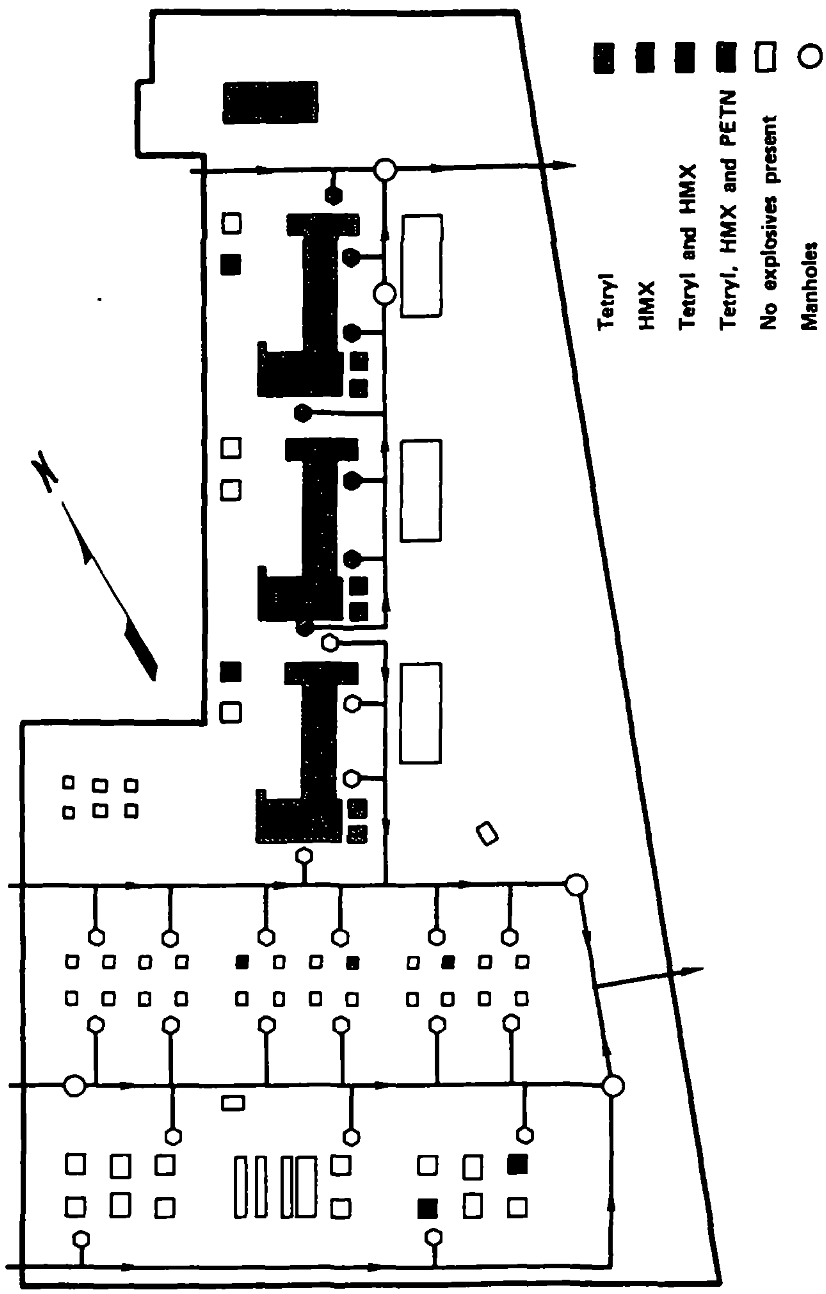


EXHIBIT 1-18

HANLEY AREA FACILITIES CONTAMINATED WITH EXPLOSIVES RESIDUES



- Conducting an asbestos survey to determine the presence of asbestos-containing material (ACM) on site (i.e., building spaces and the underground tunnel system at the Hanley Area). Samples will be taken as needed to confirm visual observation of ACM.

- Conducting a tunnel investigation to sample and analyze free standing liquid present in the tunnel system below the Hanley Area. Approximately 10 samples of the liquid will be sampled and analyzed to determine what contaminants, if any, are present in the standing liquid inside the tunnels. Sediment samples may be taken as well.

- Performing a hydrogeologic investigation if the surface soils investigation indicates the presence of contamination. The hydrogeologic investigation will include soils sampling from deep soil borings and the installation and monitoring of four groundwater monitoring wells.

- Interpreting the results to assess the nature and extent of the contamination and to evaluate abatement alternatives.

- Conduct a preliminary risk assessment based on readily available data.

- Developing alternatives for the containment, treatment, removal and/or disposal of hazardous wastes at the site. In addition to the range of abatement alternatives, options will also be developed for a limited abatement action and for "no action."

- Screening and reducing the number of alternatives by considering the alternatives against cost, effectiveness, relative ease of implementation, and other factors.

- Preparing the RI/FS reports in accordance with EPA guidelines and section C of the contract.

- Supporting government efforts to involve the public in decisions and actions at the SLOP, as appropriate and only as directed by the USATHAMA Project Officer.

1.4 REFERENCES

Colvin, W.R., and Zarzycki, J.H., 1981, Survey of the Hazardous/Chemical Area No. 2 of the Former St. Louis Ordnance Plant, Volume I, Final Report, DRXTH-FS-TR-81105.

Fenneman, N.M., 1909, Physiography of the St. Louis Area, Illinois State Geological Survey, Bulletin No. 12.

Fenneman, N.M., 1911, Geology and Mineral Resources of the St. Louis Quadrangle, Missouri-Illinois, U.S. Geological Survey, Bull. 438.

Gleason, C.D., 1935, Undergroundwaters in St. Louis County and City of St. Louis, Missouri. State of Missouri, Geological Survey and Water Resources, Bienn. Dept., 1933-1934, App. 5.

Hinchey, N.S., Fisher, R.B., and Calhoun, W.A., 1947, Limestones and Dolomites in the St. Louis Area State of Missouri, Geological Survey and Water Resources, Report of Investigations, No. 5.

Howe, W.B., 1953, Upper Marmatun Strata in Western and Northern Missouri State of Missouri, Geological Survey and Water Resources, Report of Investigations, No. 9.

Howe, W.B., 1961, The Stratigraphic Succession in Missouri, State of Missouri, Geological Survey and Water Resources, Volume 40, 2nd Series.

Hunt, C.B., 1974, Natural Regions of the United States and Canada, W.H. Freeman and Company.

Lutzen, E.E., and Rockaway, J.D., 1971, Engineering Geology of St. Louis County, Missouri State of Missouri, Geological Survey and Water Resources, Engineering Geology Series, No. 4.

Martin, J.A., and Wells, J.S., 1966, Guidebook to Middle Ordovician and Mississippian Strata, St. Louis and St. Charles Counties, Missouri, 1966 Annual Meeting, American Association of Petroleum Geologists, Report of Investigation, No. 34.

Miller, D.E., et al., 1974, Water Resources of the St. Louis Area, Missouri: Missouri Geological Survey and Water Resources, WR. 30.

Searcy, J.K., Baker, R.C., and Durum, W.H., 1952, Water Resources of the St. Louis Area, Missouri and Illinois: U.S. Geological Survey, circ. 216.

Thompson, T.L., 1986, Paleozoic Succession in Missouri, Part 4 - Mississippian System: Missouri Department of Natural Resources, Division of Geology and Land Survey, Report of Investigations, No. 70.

U.S. Department of Agriculture, 1979, Soil Survey of St. Louis County and St. Louis City, Missouri, Soil Conservation Service.

U.S. Department of the Army, U.S. Army Toxic and Hazardous Materials Agency, 1987, Geotechnical Requirements for Drilling, Monitor Wells, Data Acquisition and Reports, Attachment B, Aberdeen Proving Ground, MD.

2.0 FIELD OPERATIONS PLAN

2.1 INTRODUCTION AND GENERAL APPROACH

The objective of this task is to conduct a Remedial Investigation/ Feasibility Study (RI/FS) at the Hanley Area of the St. Louis Ordnance Plant (SLOP). The RI/FS will be conducted to: (1) determine the nature and extent of site contamination; (2) evaluate contamination migratory characteristics; (3) investigate potential contamination impact upon receptors; and (4) define alternative remedial strategies.

All operations to be conducted during this RI/FS task will be performed in accordance with the specifications contained in Contract DAAA15-88-D-0009 and Delivery (Task) Order No. 3 -- St. Louis Ordnance Plant Installation Restoration Program. Specific requirements contained and referenced in the Task Order are addressed within this section and others of this work plan and appendices. This section presents the proposed approach to conducting field activities which will enable ICF to meet those objectives presented in Section 1.3--Scope of Site Investigation.

The remedial investigation will proceed in a two-phased approach. The first phase includes a surface soil investigation to determine the nature and extent of surface soil contamination. In addition, ICF will conduct an asbestos-location survey in all building spaces and inside the tunnel system which is underneath the Hanley Area. Free-standing liquids and sediments in the tunnel system will also be sampled and analyzed as part of Phase I of the Remedial Investigation.

If the analytical results from the surface soil investigation (Phase I) indicate that there is extensive surface soil contamination, then ICF will proceed with Phase II which is a subsurface soil investigation and a hydrogeologic investigation. The subsurface soil investigation will include deep soil boring and soil sampling analysis. In addition, a hydrogeologic investigation will be conducted which will include the installation, development and monitoring of four groundwater wells. The subsurface soils investigation and hydrogeologic investigation will not be conducted without the authorization of the USATHAMA Project Officer. A geologist will be on site during performance of all field activities to supervise sampling and drilling operations.

Soil samples (including sediments) will be analyzed for explosives, ICAP metals, mercury, and other contaminants as appropriate. The presence of some chemical compounds will be assessed by analyzing for indicator chemicals of these compounds (e.g., mixers and powders will be assessed by analyzing for indicator chemicals of these compounds, such as lead, aluminum, barium, and magnesium). A similar approach will be applied to the analysis of liquid samples. Free standing liquids (surface water) will be analyzed for explosives, ICAP metals, mercury, volatile and semi-volatile organics, and anions (Cl, SO_4, NO_3/NO_2). Groundwater samples will be analyzed for explosives, ICAP metals, mercury, volatile and semi-volatile organic contaminants, and anions (Cl, SO_4, NO_3/NO_2).

ICF's proposed methodology for conducting the SLOP RI/FS complies with all USATHAMA and EPA geotechnical and QA/QC requirements, and has been fully integrated into a Health and Safety Plan (see Section 7) developed for the site.

2.2 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are qualitative and quantitative statements which specify the quality (e.g. level) of the data that will be required to support decisions made regarding remedial response activities. Development and use of data quality objectives is an USEPA requirement for conducting CERCLA projects and has been described by EPA in their guidance document "Data Quality Objectives for Remedial Response Activities" (March 1987). DQOs are developed for remedial programs to help ensure that data obtained during remedial programs is of sufficient quality to support remedial response decisions, reduce overall costs of data sampling and analysis activities, and accelerate project planning and implementation.

The data quality objectives that have been developed for field activities at the SLOP, as discussed below, also take into consideration USATHAMA geotechnical requirements for drilling, monitor wells, data acquisition, and reports as specified in the USATHAMA Geotechnical Requirements document (March 1987). These requirements were developed to serve a similar purpose to that of EPA DQOs; the application of these requirements is intended to provide acceptable technical data and tracking procedures to accurately obtain, describe, and evaluate representative samples of the surface and subsurface environment and to characterize and appraise the contamination potential of the site. While EPA DQO procedures focus more on guaranteeing the validity and certainty of analytical results, USATHAMA requirements are targeted as well toward guaranteeing the quality and representativeness of data collected during field activities.

A summary of data quality needs and objectives that have been developed for the SLOP RI/FS are presented in Exhibit 2-1. For each field activity that is planned for the SLOP site, this exhibit summarizes:

- the objectives of collecting data from the media associated with each field activity;

- the data types needed to meet the objectives, both chemical analytical parameters and physical parameters; also included is the estimated number of data that should be collected to meet the data objective;

- a description of the sampling method being employed for each type of data, whether environmental or source, biased or grid, grab or composite, non-intrusive or intrusive, and phased or other;

- the use or uses for which the data are being collected; this has been described by using general purpose categories which represent different data uses (e.g Risk Assessment);

EXHIBIT 2-1

DATA QUALITY OBJECTIVES AND NEEDS SUMMARY - SLOP RI/FS

	Phase I Activities			Phase II Activities	
	Surface Soil Sampling	Surface Water/Sediment Sampling	Asbestos Sampling	Subsurface Soil Sampling	Groundwater Sampling
Objective	Surficial soil samples will be taken, classified as per USATHAMA geo-technical requirements, and analyzed to determine the types, levels, and horizontal extent of hazardous contamination, the associated ingestion/contact threat, and to develop remedial alternatives.	Surface water and sediment samples will be taken to determine the types and levels of contamination in tunnels, the associated ingestion/contact threat, and to develop remedial alternatives.	Visual observations will be made and asbestos samples will be taken to from locations where asbestos was used for insulation (in tunnels & buildings) to determine the inhalation threat and to develop remedial alternatives. Total Organic/inorganic vapor detection will be conducted using portable instruments to aid in Site Characterization/ Health & Safety.	Soil samples will be taken, classified according to USATHAMA geotechnical requirement, and analyzed to determine the horizonatal and vertical extent of contaminents, provide input to the risk assessment, and provide information to evaluate remedial alternatives.	Monitoring wells will be installed, wells will be logged as per USATHAMA, geotechnical requirements aquifer testing will be conducted, and groundwater samples taken and analyzed to evaluate the extent of media contamination, develop a risk assessment, and assess potential remedial alternatives.
Data Types and Numbers					
Chemical Data	- Metals, Explosives Total=41	- Metals, Explosives, Total=10 (up to) water; - Organic/inorganic vapors Total=6 (up to) sediment; - pH, Conductivity, Total=To be field determined	- Asbestos, Total=100	- Metals, Explosives Total=To be field determined	- VOAs, Metals, Explosives Total=4 - pH, Conductivity. Total=To be field determined
Physical Data	None	- Temperature Total=To be field determined	- Quanity Estimates Total=To be field determined	None	- Temperature Total=To be field determined - Well logging Total = 4 wells - Grain size, Atterberg Limits, Moisture Content Total=24 to 48 - Slug Testing, pump tests Total=4
Sampling Method					
Chemical Data	Environmental, biased, grab, intrusive	Environmental, biased, grab, nonintrusive	Source, biased, grab, intrusive.	Environmental, biased, grab, intrusive.	Environmental, biased, composite, intrusive
Physical Data	--	Environmental, biased, grab, nonintrusive	Visual observation	--	Visual Observation, Environmental, biased, grab, nonintrusive

EXHIBIT 2-1 (Continued)

DATA QUALITY OBJECTIVES AND NEEDS SUMMARY - SLOP RI/FS

	Phase I Activities			Phase II Activities	
	Surface Soil Sampling	Surface Water/Sediment Sampling	Asbestos Sampling	Subsurface Soil Sampling	Groundwater Sampling
Data Use	Risk Assessment, Site Characterization, Evaluation of Alternatives, Engineering Design	Risk Assessment, Site Characterization, Evaluation of Alternatives, Engineering Design	Risk Assessment, Site Characterization, Evaluation of Alternatives, Engineering Design, Monitoring During Implementation.	Risk Assessment, Evaluation of Alternatives, Engineering Design	Risk Assessment, Evaluation of Alternatives
Analytical Levels					
Chemical Data	USATHAMA Certified Analysis (EPA Level IV), Soil analyses will be performed in an off-site USATHAMA certified laboratory. This level requires rigorous QA/QC protocols.	USATHAMA Certified Analysis (EPA Level IV). Water and sediment analyses will be performed in an off-site USATHAMA certified laboratory. This level requires rigorous QA/QC protocols. Field Screening using portable pH and conductivity instruments (EPA Level I). Results are not quantitative or compound specific. Instruments periodically calibrated (single or dual point).	Non-certified Analysis (EPA Level III). Asbestos analyses will be performed in an off-site laboratory. Analyses similar in precision and accuracy to USATHAMA Certified Analysis, but laboratory is not certified. Visual observations of asbestos locations, similar to Field Screening, EPA Level I.	USATHAMA Certified Analysis (EPA Level IV). Soil Analyses will be performed in an off-site USATHAMA certified laboratory. This level requires rigorous QA/QC protocols.	USATHAMA Certified Analysis (EPA Level IV). Water Analyses will be performed in an off-site USATHAMA certified laboratory. This level requires rigorous QA/QC protocols. Field Screening using portable pH and conductivity instruments. Results are not quantitative or compound specific. Instruments periodically calibrated (single or dual point).
Physical Data	--	Field Screening using portable temperature instrument (EPA Level I). Results are not quantitative or compound specific. Instruments periodically calibrated (single or dual point).	Field Screening using portable vapor detector instruments (EPA Level I). Results are not quantitative or compund specific. Instrument periodically calibrated (single or dual point).	--	Visual logging of monitoring wells, similar to Field Screening EPA Level I. Field Screening using portable temperature instrument (EPA Level I). Field Analysis using portable slug and pump test instruments -- similar to EPA Level II. Precision and accuracy are measured or calculated. Results are available real time. Grain size, Atterberg Limits, moisture content Analysis by ASTM methods --similar to EPA Level V. Analyses performed in off-site laboratory which may or may not be certified.

- the identification of an appropriate analytical level for the analysis (or measurement) being performed; five such levels have been defined by EPA for chemical analyses; these have been slightly modified to take into account physical measurements and laboratory certification by USATHAMA (as opposed to EPA's Certified Laboratory Program); for each category of data use, several analytical levels may be appropriate; and

- the Quality Control associated with each sample, analysis, or measurement; this aspect of data quality is discussed in detail in the Project Quality Control Plan (see Section 5.0 and Appendix A) and in this section and Section 4.0, Laboratory Analysis, and has been developed by incorporating USATHAMA Geotechnical Requirements into the field operations plan.

2.3 SURFACE SOIL, TUNNEL, AND ASBESTOS INVESTIGATION

As stated in Section 2.1, remedial investigation activities (field) for the SLOP will be conducted in two phases--the first phase consisting of surface soil sampling, surface water and sediment sampling from the site's tunnel system, and asbestos surveying and sampling from on-site buildings and the tunnels; the second phase consisting of subsurface soil sampling and a hydrogeologic investigation that would include monitor well installation and groundwater sampling. Phase I field activities are scheduled to begin in June and will last up to three weeks. These activities and ICF's plan for conducting them are described below; these activities will be performed with strict adherence to USATHAMA requirements, the Health and Safety Program (Section 7), and the Project Quality Control Plan (Appendix A).

2.3.1 Soil Sampling

Surface soil samples (i.e., less then one foot) will be obtained to delineate the horizontal extent of contamination at SLOP. Samples will be taken at a shallow depth sufficient to penetrate any soil top-dressing that has resulted from recent site regrading and seeding. The analytical results of the soil investigation will be used to determine the need for deeper soil sampling and monitoring well installation to define the vertical extent of contamination (Phase II). Up to 41 shallow soil samples will be obtained and analyzed for explosives, ICAP metals, and mercury from various locations around the Hanley Area. At least 10 percent of this number will be collected from a location(s) deemed to be representative of background conditions at the site (Data Quality Objectives for Remedial Response Activities, EPA 68-01-6939, 1987). In addition, at least one rinsate sample will be collected during sampling operations.

Preliminary locations for collection of surface soil samples were identified and staked during the April 11-12, 1989 site visit. Descriptions of these locations are given in Exhibit 2-2, and a detailed site map showing soil sampling locations is presented in Pocket B located at the end of this work plan.

EXHIBIT 2-1 (Continued)

DATA QUALITY OBJECTIVES AND NEEDS SUMMARY - SLOP RI/FS

	Phase I Activities			Phase II Activities	
	Surface Soil Sampling	Surface Water/Sediment Sampling	Asbestos Sampling	Subsurface Soil Sampling	Groundwater Sampling
Quality Control					
Samples	Standard Matrix Spikes Method Blank Internal Laboratory Standards Rinse Blanks Rinse Water Analysis	Standard Matrix Spikes Method Blank Internal Laboratory Standards Rinse Blanks Rinse Water Analysis	Insulation Samples collected to verify visual observations	Standard Matrix Spikes Method Blank Internal Laboratory Standards Rinse Blanks Rinse Water Analysis	Standard Matrix Spikes Method Blank Internal Laboratory Standards Rinse Blanks Rinse Water Analysis Drilling Water Source Analysis
Procedures	Adherence to requirements of Project Quality Control Plan	Adherence to requirements of Project Quality Control Plan	Adherence to requirements of Project Quality Control Plan	Adherence to requirements of Project Quality Control Plan	Adherence to requirements of Project Quality Control Plan

EXHIBIT 2-2

SOIL SAMPLING LOCATIONS

SAMPLE NUMBER	BUILDING REFERENCE	DESCRIPTION OF LOCATION
SS01	218C	Southeast corner of bldg., in front of Room 109
SS02	218C	East side of bldg., in front of Room 116
SS03	218C	East side of bldg., in front of Room 122
SS04	218B	East side of bldg., in front of Room 107
SS05	218B	East side of bldg., in front of Room 110
SS06	218B	East side of bldg., in front of Room 122 near fence
SS07	218A	East side of bldg., in front of Room 116
SS08	218A	East corner of bldg., in front of Room 132
SS09	218 & 219	Between bldgs. 218 & 219, near sidewalk to Bldg. 220
SS10	218A	West side of bldg., in front of Room 123
SS11	219, Structure C	North corner of "C" (Brick bunker house), inside bunker
SS12	218A	West side of bldg., in front of Room 113
SS13	218B	West side of bldg., in front of Room 121
SS14	218B	West side of bldg., in front of Room 111
SS15	219, Structure H	South corner of "H," inside bunker, in front of "H"
SS16	219, Structure H	West corner of "H," inside bunker, behind "H"
SS18	219C	West side of bldg., in front of Room 123
SS19	219C	West side of bldg., in front of Room 117
SS20	219C	West side of bldg., in front of Room 113
SS17	219C	West side of bldg., in front of Room 102
SS21	227	North side, outside of bunker, near "M"
SS22	228	North side, outside of bunker, near powder well of structure "F"
SS23	Near entrance to site	East side of fence near the gate
SS24	At background monitoring well site	Well #1, west side of site fence
SS25	219G	East corner of bldg., corner of loading dock
SS26	219G	West side of bldg., in front of door to Room 01
SS27	219G	West side of bldg., in front of door to Room 02
SS28	219G	West side of bldg., in front of door to Room 03
SS29	219G	North side of bldg., on west side of tunnel vent
SS30	219D	West side of bldg., in front of door to Room 01

EXHIBIT 2-2 (continued)

SOIL SAMPLING LOCATIONS

SAMPLE NUMBER	BUILDING REFERENCE	DESCRIPTION OF LOCATION
SS31	219D	West side of bldg., in front of door to Room 01
SS32	219A	Southwest corner of bldg.
SS33	219A	West side of bldg., in front of door to Room 02
SS34	South side of DOL Guard House	Near fence & sidewalk, near Mon. well #4
SS35	Fence at Goodfellow Ave.	East of Bldg. 219D downslope
SS36	219G-D	Downslope near Goodfellow Ave., north side of tunnel entrance
SS37, 38,39	Near "Maintenance bldg.," 220 (old chemical lab)	On DOL Area, northeast of the Hanley Area

Sample bottles, blue ice, and sample containers will be used for collection of the soil samples and will be obtained by the ICF field team members from the USATHAMA designated Class laboratory, Metatrace, ([314] 298-8566) upon arrival by the team in June. This laboratory is located within a short driving distance of the site, facilitating equipment pickup and sample drop off. Sample bottles will be pre-cleaned by the laboratory according to the protocols required by USATHAMA and detailed in the Project Quality Control Plan (Appendix A). ICF chain-of-custody forms will be sent to Metatrace ahead of the sampling activities for inclusion in the sample containers.

Distilled water that will be used for decontamination of soil sampling--and other media--equipment will be supplied by Fisher Scientific in 5-gallon polyethylene-lined containers. The water that will be used is classified as "ultra-filtered deionized water." A sample of this class of water will be sent to the USATHAMA designated Class laboratory, Metatrace, prior to arrival of the field team at the site. The water sample will be analyzed for explosives, ICAP metals, Hg, volatile and semi-volatile organic constituents, and anions (Cl, SO_4, NO_3/NO_2) constituents. Results of this analysis will be submitted to USATHAMA for approval.

Surface soil samples will be collected in clean 250-ml wide-mouth, amber, glass bottles with Teflon lined caps. Soil samples will be collected by the following procedure: A boring will be made to a depth of approximately one foot using a clean stainless steel scoop or shovel. Excavated soil will then be placed into a stainless steel pan or on a clean polyethylene plastic sheet. The soil will be mixed to produce a more homogeneous mixture. Sample bottles will be filled using a stainless steel spatula/scopola until the sample bottle is completely full. Traces of soil remaining on the sample bottle and threads will be completely removed using a clean paper towel, and the cap immediately tightened. Sampling equipment will be placed on disposable polyethylene plastic sheeting spread on the ground at each sampling location.

Immediately after sample collection, samples will be placed in the sample cooler and maintained at 4°C. Chain of custody forms will be completed, and enclosed in the sample containers or coolers. Soil samples will then be hand delivered to the laboratory at the end of the day or at the start of the next day. It is estimated that the field team will complete the surface sampling within 5 working days.

All measurements and information regarding sampling activities will be recorded in a permanently-bound logbook with numbered pages. Information to be recorded will include: sample number; depth of sample; visual observations of sample including color, water content, and composition; date and time sample collected; and the parameters to be analyzed. All pages associated with the sampling activities will be signed and dated by the samplers, and reviewed and signed by the Field Operations Leader.

Sampling equipment used to obtain soil samples will be cleaned with deionized water prior to use at the next sampling location to prevent cross-contamination between locations. All sampling equipment will be rinsed with the USATHAMA-approved deionized water. Hollow stem augers will be steamed cleaned and rinsed with approved water between borings. An equipment rinsate sample will be taken to confirm the effectiveness of the decontamination procedure. Detergents, soaps, or solvents will not be used to clean equipment in the field.

2.3.2 Tunnel Sampling and Survey

Surface Water Samples. In order to characterize the quality of the standing water in the tunnel system beneath SLOP, a limited sampling program consisting of up to 10 samples is planned. Surface water samples (i.e., standing liquid samples) will be collected in the tunnel at locations to be field determined. In addition, one rinsate sample will be collected as appropriate. Aqueous samples will be analyzed for explosives, ICAP metals, Hg, volatile and semi-volatile organic constituents and anions (Cl, SO_4, NO_3/NO_2). As with soil samples, sample bottles and containers and blue ice, will be obtained from Metatrace.

All sampling equipment will be thoroughly cleaned with the USATHAMA approved distilled water prior to sampling. Prior to sampling at each location, pH, conductivity, and temperature parameters will be measured and recorded in a bound logbook. Total depth of standing water, depth of sample, time of sampling, and any other observations will also be recorded.

All samples will be collected using a pond sampler or by submerging the appropriate-sized sample container into the standing water. Sampling activities will be performed in a manner that will minimize disturbance to the water surface. Sample containers will be triple-rinsed with sample water prior to filling. Samples for volatile organic constituents will be placed into duplicate, clean, 40-ml, septum-topped, screw-capped, VOA vials. Semivolatile organic samples will be collected in a 1-gallon, wide mouth amber glass bottle with a teflon lid. Samples required for anion analysis will be collected in two 8 oz bottles which have been cleaned using USATHAMA bottle cleaning procedures. Sulfuric acid will be added to one sample container as a preservation. Samples for metals analysis will be filtered in the field through a clean 0.45 micron filter. Filtered water will be collected into a clean 1-liter polyethylene bottle, triple-rinsed with the filtered water prior to filling, and preserved with nitric acid to pH 2. Samples for explosives analysis will be collected into clean 1-liter, wide-mouth, amber, glass bottles with Teflon lined caps. Four sample bottles will be used to collect samples. Explosives samples will not be filtered. After collection samples will be immediately placed into the sample cooler and maintained at 4°C. Sample coolers will be delivered to Metatrace at the end of the day or the start of the next day.

Sediment Samples. Sediment samples from the tunnels may also be collected at the same time and location (as determined by Field Operations Leader) as surface water samples. Sediment samples will be collected after the corresponding surface water sample in order to minimize suspension of sediment. Samples will be collected using a stainless steel scoop or a hand corer. Sediment samples will be collected for both explosives and metals analysis into a clean 250-ml wide-mouth, amber, glass bottle with a Teflon lined cap. All sampling equipment will be thoroughly cleaned between sample locations using approved distilled water and triple rinsed with surface water from the sample location prior to sampling. Samples will be maintained at 4°C and delivered to the laboratory along with the surface water samples.

If sufficient accumulated sediments are found in the tunnels, up to 6 sediment samples and a rinsate sample (as appropriate) will be taken from inside the tunnel system at the direction of the USATHAMA Project Officer.

All tunnel sampling activities including sample depth; time; and relevant observations will be recorded in a bound logbook in accordance with USATHAMA protocols.

2.3.3 Building and Tunnel Asbestos Sampling and Survey

ICF personnel will inspect all accessible areas for the presence of asbestos containing materials (ACMs) at the St. Louis Ordnance Plant during the June sampling event. The EPA definition of ACM as a material with greater than 1 percent by weight asbestos will be used. The asbestos location survey will include building spaces, building materials, and the tunnel system. (A site map indicating the tunnel system under the Hanley Area is provided in Pocket C at the end of this work plan.) Any area that is not readily available to ICF personnel (e.g., locked room) will be noted as such and attempts will be coordinated with USATHAMA to enter these areas for the assessment of ACM. ICF personnel will conduct the asbestos location survey in accordance with the Health and Safety Plan. Personal protective equipment will include paper Tyvek suits and full face air purifying respirators equipped with high efficiency particulate air (HEPA) cartridges as appropriate.

Selected samples of suspect insulation and suspect building materials will be taken during the asbestos location survey in the building spaces and tunnels. The sampling surface will be sprayed with water prior to removal of the sample. This will act to minimize the generation of airborne fibers. A coring tool will be used to extract samples and insure that an entire cross section of the suspect material is present in the sample. The samples will be placed in polyethene bags and appropriately labeled. Each sample will be analyzed for asbestos type and amount using polarized light microscopy in combination with oil dispersion staining techniques. The analytical method will be consistent with EPA Method 600/M4-82-020 "Interim method for the determination of asbestos in bulk insulation samples." All sample locations will be indicated on a site map and with an appropriate designation at the sampling point. Any potentially friable ACM will be suitably plugged and covered with an adherent gauze material. ICF will send all field samples to: Certified Engineering & Testing Company (CETCI), 25 Mathewson Drive, Weymouth, MA ([617] 849-0111).

Appropriate physical inspection of all accessible insulating materials will be made. This inspection will include examination of insulation for color, texture, damage, and friability. It is possible to identify "homogeneous areas" within functional spaces by physical inspection coupled with analytical results for asbestos analysis. "Homogeneous areas" consist of areas that are the same with regard to physical appearance along with their presence or absence of asbestos. Special consideration will be given to additional bulk sampling of materials which often vary in asbestos content. Depending on preliminary findings from the visual inspection, it is expected that up to 10 samples will be taken for asbestos analysis.

Based on the results of the physical inspection, "red" and "blue" field notations will be used to indicate ACM and non-ACM, respectively. These notations will be made in building material and within the tunnels as appropriate. Materials that are believed to contain asbestos will be so designated by a 2-inch diameter red spray paint mark every 15 feet. Any insulation material that is examined and ICF believes not to be ACM will be indicated with a 2-inch diameter blue spray paint mark every 15 feet. As with ACM, spray paint marks will be made more frequently in the event of changes in the homogeneity of the insulation material.

While performing the asbestos location survey at the St. Louis Ordnance Plant, ICF personnel will note all possible ACMs that are damaged (e.g., water damage, damage to pipe lagging cover). A damaged homogeneous area that contains asbestos will so designated if at least 10 percent of any ACM surface is not intact or shows water damage. When appropriate, ICF personnel will also sample possible ACM that has fallen to the floor. Asbestos contaminated areas will be noted in the report.

If laboratory analysis of site materials indicate the presence of asbestos, ICF will prepare sufficient narrative and indications on a site plan of the locations of the ACM. ICF will also return to the site and update/correct the red/blue field notations as appropriate.

2.4 SUBSURFACE SOIL AND HYDROGEOLOGIC INVESTIGATION

Based on the results of the June surface soil investigation and discussions with the USATHAMA Project Officer, a subsurface soil and hydrogeologic investigation may be performed. If the surface soil samples indicate that contamination is extensive, four groundwater monitoring wells will be installed and a subsurface boring program using hollow stem augers and split spoon samples will be performed. If contamination at the site appears to be low, deep subsurface soil borings and the installation of groundwater monitoring wells will be considered but may not be deemed necessary, due to the relatively immobile properties of the contaminants of concern. Field activities will likely commence in September 1989. The planned approach for conducting these investigations is presented below.

2.4.1 Subsurface Soil Sampling

If contamination is relatively extensive at SLOP, as indicated by the results of the surface soil sampling investigation, subsurface soil samples will likely be obtained to further characterize the vertical extent of contamination at SLOP. The location and number of subsurface borings will be determined after review of results from the surface soil investigation and discussions with the USATHAMA Project Officer.

Subsurface soil samples will be taken at five foot intervals, to a depth of twenty feet. Samples will be obtained using a split spoon sampler driven through a hollow stem auger drill rig. Samples will be obtained from the interior of the core, so that the possibility of cross-contamination from the walls of the sampler is minimized. Soil samples will be analyzed for both metals and explosives analysis and will be collected into a clean 250-ml wide-mouth, amber, glass bottle with a Teflon-lined cap. The sample volume of 250 mL will be sufficient enough for metals analysis using ICAP and CV techniques since both require only a sample volume of 1 gram, and explosive analysis which requires a total volume of 5 grams. A rinsate sample(s) will be collected as appropriate.

Immediately after sample collection, samples will be placed in sample coolers and maintained at 4°C. Chain of custody forms will be completed and included in coolers. Coolers will be hand delivered to the laboratory at the end of the day or the beginning of the next day.

The sampling equipment will be thoroughly cleaned between samples by rinsing the equipment three times with USATHAMA approved deionized water. The hollow stem auger will be steam cleaned and rinsed with approved water between borings. All sampling procedures, sample depth, sample interval, sample time, and any observations of sample conditions will be recorded in a bound logbook.

2.4.2 Monitoring Well Installation

The installation of monitoring wells will be conducted if the analytical results of the surface soil samples collected in June 1989 indicate contamination is extensive at SLOP. All field operations outlined in this section will be conducted with strict adherence to the USATHAMA Geotechnical Requirements (March, 1987), the Health and Safety Plan, and the Project Quality Control Plan (Appendix A) developed for this task.

In order to gain information about groundwater quality, site stratigraphy, and groundwater movement at this relatively small site, a total of four monitoring wells are proposed for installation at SLOP. Well sites have been preliminary located and staked during the initial site visit conducted on 11-12 April, 1989 (a USATHAMA hydrogeologist participated with the reconnaissance survey), and on a conceptual model of groundwater flow -- assuming groundwater is controlled by topography. A site map showing the approximate locations of the proposed monitoring wells is presented in Pocket D located at the end of this work plan. Three monitoring wells will be located on the east side of the Hanley Area, downgradient, in the direction of groundwater flow. The fourth well will be located upgradient on the west side of the study area (outside the area fence) to serve as a background well.

Well Drilling. Due to the lack of wells in the vicinity of the SLOP, it will not be possible to obtain an untreated source of water for drilling activities. Drilling water will be obtained from a hydrant located in the maintenance yard of the U.S. Army Reserve building adjacent to the investigation site. This water is provided by a public utility and is chlorinated. A sample of this water will be obtained prior to conducting drilling and will be sent to the USATHAMA Class lab for analysis of contaminants of interest. Since the use of treated water is a non-standard operating procedure, efforts will be undertaken as necessary to ensure representative samples of groundwater are obtained; this may include additional development of wells to ensure the removal of any residual chlorine.

Boreholes for all monitoring wells will be advanced through unconsolidated residuum using a 6.25 inch outside diameter hollow-stem auger. Split spoon samples will be collected at a minimum of 5 foot intervals and at each major change in lithology, whichever occurs first. Based on background information gained from geologic literature, it is estimated that residuum in the vicinity of SLOP is approximately 20 to 30 feet thick.

When auger refusal is achieved, the hollow stem augers will be withdrawn. The boring will then be reamed with mud rotary drilling using an 8-inch bit. Mud rotary drilling will be completed to a depth of 5 feet below the depth of auger refusal (i.e., the bedrock surface). When this depth is reached, the mud rotary drilling tools will be removed and 8-inch schedule 80 PVC temporary casing will be placed in the boring and sealed into the bedrock with bentonite pellets. The drilling mud will then be excavated from the hole. Drilling will then be continued using a 2-inch diamond bit core barrel to core down, while collecting rock core samples (at 5 foot intervals), to a depth just below the groundwater surface. It is expected that groundwater will be encountered at approximately 100 feet beneath the ground surface. Once the coring is completed, the rock hole will be reamed using air rotary drilling with a 6-inch bit, to prepare the boring for installation of 2-inch PVC monitoring well. An air line oil filter will be used to filter all air supplied from the air compressor to the drilling operations. A sample of the compressor lubricating oil will be provided to the USATHAMA prior to drilling operations. The type and model number of the air compressor will also be reported to USATHAMA. At the completion of the well, the 8-inch temporary PVC casing will be left in place (to help prevent vertical migration of contaminants down into the bedrock from the overburden soils) or removed, based on review of site conditions and discussions with the USATHAMA Project Officer.

Drilling activities will be supervised by the on-site geologist who will maintain a detailed drilling log, describe the samples and cores using the Unified Soil Classification System and visual descriptions, log discontinuities in rock, and ensure that the drilling is performed in accordance with USATHAMA requirements. Original bore logs will be submitted to USATHAMA within 3 days of completion of the well. A representative portion of each split spoon sample will be placed in a sample jar to be archived. Rock cores will be collected, wetted, photographed, and placed in wooden-core boxes, as per USATHAMA requirements. All samples collected will be stored on-site at a USATHAMA designated location.

No evidence exists that overburden water (i.e., perched water) will be encountered above the bedrock aquifer, and it is not anticipated that drilling efforts will encounter a substantial ground water layer. However, if a shallow or perched aquifer is encountered during the drilling of the monitoring wells the permeability of the materials will be assessed in which the aquifer is located as well as the potential for migration of contaminants contained within the aquifer. Information from this assessment will be provided by well logging records and lithologic samples collected. If such an aquifer is encountered and assessed to be a potentially contaminated and/or a pathway for migration, the USATHAMA Project Officer and the Project Geologist will be consulted to determine whether the well(s) should be established and completed in the shallower aquifer.

Appropriate decontamination procedures will be followed between drilling of the wells to prevent cross-contamination between samples and boreholes. The drill rig, rods, augers, bits, casing, and other equipment will be steam cleaned prior to use on site and after each boring has been completed; sampling equipment will be rinsed with USATHAMA approved distilled water. Boreholing cuttings, drilling fluids, and drilling water will be disposed of onsite.

Well Installation. Because of low water yields from the aquifer, monitoring wells will be constructed of 2-inch diameter, schedule-80 PVC, threaded flush-joint casing pipe and 15-foot long, machine-slotted screens (a 10-foot screen joined with a 5-foot screen). Schedule-80 PVC will be used to ensure sufficient wall strength for the deep 2-inch wells. The slot size for all screens will be 0.010 inch. A flush-threaded PVC bottom plug will be placed at the bottom of the screen. No PVC solvents or glues will be used for any of the well installation activities at the site.

After the PVC has been installed, a filter pack of clean, uniform, 8-12 mesh quartz sand, pre-approved jointly by the USATHAMA Project Officer and ICF geologist prior to drilling, will be placed around the screen to a height of at least 5 feet above the top of the screen. A 5-foot bentonite seal will be installed following emplacement of the filter pack using high density, 1/4 inch diameter bentonite pellets, also pre-approved jointly by the USATHAMA Project Officer and ICF geologist. The bentonite seal will be allowed to swell for a minimum of 1 hour. The remainder of the annulus will then be backfilled with a pumped cement-bentonite slurry made from a 20:1 (by weight) mixture. A steel protective casing with a locking cap will be installed over the wellhead. All locks will be operable with a single key. A coarse gravel blanket and three protective posts will be placed around each well as described in the USATHAMA Geotechnical Requirements. Wells will then be painted and numbered with fluorescent orange paint.

Well Development. At least 48 hours after placement of the internal mortar collar, wells will be developed using a submersible pump supplemented with a bottom discharge/filling bailer, if necessary. At a minimum, at least five times the measured amount of total fluids lost while drilling, plus five times the combined amount of standing water, annular water, and that used in filter pack placement will be withdrawn from the well. Additional development may be necessary until the well water is clear and the sediment thickness within the well is less than one percent of the screen length. Additional development may also be necessary due to residual chlorine as previously discussed.

The visual appearance of the groundwater, pH, temperature, and conductivity of the well water will be monitored and recorded to determine development completeness and to monitor the integrity of the grout seal. The on-site geologist will supervise all well development activities and prepare as-built diagrams of well construction and development water quality reports to be submitted with the original well logs.

Monitoring Well Survey. Well locations will be surveyed by a licensed surveyor to determine map coordinates and elevations. State Planar coordinates will be surveyed within $\pm$3.0 feet, and the elevations will be surveyed to within $\pm$ 0.05 feet, using the Natural Geodetic Vertical Datum of 1929. Survey elevation measurements will be performed for each well from the natural ground surface and the highest point on the rim of the uncapped well casing.

2.4.3 Geotechnical Testing

Physical soil analyses will be conducted on approximately 6 to 12 samples obtained fórm each well drilled, depending on the range and frequency of soil types encountered. Soil testing will be representative of the geographic and geologic environments encountered at SLOP. Tests shall include Atterberg Limits, sieve grain size distribution, and assignment of Unified Soil Classification System symbols. Laboratory and summary sheets will be submitted to the Contracting Officer Representative (COR) and copies included in the final RI/FS report.

2.4.4 Aquifer Testing

To determine the hydraulic conductivity of the aquifer, and to quantify the groundwater flow rate and direction, simple slug tests will be performed in the installed wells. A 1.25-inch diameter by 3 or 5-foot long slug will be used for both falling-head and rising-head slug tests. The variation in water level will be monitored with a pressure transducer and digital data logger, such as the Hermit 1000 or equivalent. The data acquisition rate will be adjusted for each well to permit recording of sufficient data for analysis. At least two cycles of the slug will be recorded.

Data will be interpreted from elevation-versus-time plots, using commercially-available software. Estimates of the aquifer transmissivity will be obtained from the data analysis.

2.4.5 Geotechnical Assessment

After validation of all field and laboratory data, a geotechnical assessment will be preformed to characterize the extent of contamination and the potential for off-site migration of contaminants. Analysis of soil borings and boring logs will be used in conjunction with geological background information to develop a three-dimensional, hydrogeologic model of the stratigraphy at SLOP. Aquifer transmissivity data will be analyzed to calculate hydraulic conductivity to determine the rate of contaminant transport. Water level measurement data from monitoring wells will be compared to determine groundwater flow direction.

2.4.6 Well Sampling

Groundwater samples will be collected from the newly installed monitoring wells at the site. Wells will be sampled in the general order of increasing contaminant concentrations, as determined (if possible) from the drilling operations and surface soil data. Samples from the wells will be analyzed for explosives, ICAP metals, Hg, volatile and semi-volatile organics, and anions (Cl, SO_4, NO_3/NO_2). Field blanks, trip blanks, and rinsate samples will also be collected as appropriate.

Prior to sample collection, the water level with respect to the top of the casing will be measured with a clean electric well probe and recorded in the field notebook. An initial sample will be withdrawn for pH, conductivity, and temperature measurements. Wells will be purged using a clean stainless steel bailer until 5 equivalent volumes (including both well volume and sand pack) are removed, or until the well is evacuated. If wells which go dry during purging are found to recharge in a reasonable (less than 2 hours) time interval, the well will again be purged prior to sampling. Measurements of pH, temperature, and conductivity will be made at least once during the purging, and immediately after the purge/recharge is completed.

All well purging equipment will be thoroughly cleaned between wells using USATHAMA approved distilled water. All sampling equipment will be placed on disposable polyethylene plastic sheeting spread on the ground at the well site in order to prevent contamination of ground water samples.

After the wells have been purged and/or after recharge has occurred, samples will be obtained with the same bailer used for purging. Samples for volatile organic constituents will be placed into duplicate, clean, 40-ml, septum-topped, screw-capped, VOA vials. Semivolatile organic samples will be collected in a 1-gallon, wide mouth amber glass bottle with a teflon lid. The bottle will be rinsed three times with sample water prior to collection. Samples required for anion analysis will be collected in to two 8 oz bottles which have been cleaned using USATHAMA bottle cleaning procedures. Sulfuric acid will be added to one sample bottle, while no preservative will be added to the remaining bottle. The sample bottle will be rinsed three times with sample water prior to actual sample collection. Samples collected for explosives analysis will be collected into clean 1-liter, wide-mouth, amber glass bottles with Teflon-lined caps. Since several of the methods require a analysis volume of 500 mL, samples for explosives will be collected in four 1-liter bottles. Metals samples will be collected into one clean, 1- liter polyethylene sample bottle. Metal samples will be filtered in the field through a clean 0.45 micron filter, and preserved with nitric acid to a pH less than 2.0. Samples for explosives and volatile organic analysis will not be filtered. Immediately after collection, samples will be placed in the sample cooler maintained at 4°C. Sample coolers will be packed, together with a copy of the completed sampling and transmittal forms, and hand carried to the laboratory at least every other day. It is expected that all wells can be sampled within two days.

All measurements and a record of sampling activities will be recorded in a permanently-bound logbook with numbered pages and on the sample transmittal forms contained in the sample cooler at the time of sampling. Information to be recorded includes: well identification, water level and total well depth measurements; calculated water purge volume; field measurement results for temperature, conductivity, and pH of the purge water; observations during purging activity such as water color, depth to water level, whether the well goes dry, and estimated recharge rate; and actual total quantity of water extracted from well. Ground water sampling information to be entered into the logbook will include: date and time sample collected; decontamination procedures for sampling equipment; and the analytical parameters sampled for at the site and sampling procedures (i.e., samples filtered, chemical preservatives used).

As with other field activities, all pages associated with each day's activities will be signed and dated by the samplers, and reviewed and signed by the Field Operations Leader.

3.0 RISK ASSESSMENT PLAN

In this section, potential human health and environmental impacts associated with the SLOP site (Hanley Area) are preliminarily evaluated and the proposed approach and scope of the risk assessment to be conducted as part of the remedial investigation (RI) are outlined. The preliminary risk assessment presented in Section 3.1 is based on data collected during past sampling activities and is conducted to preliminarily identify potential risk at the site in the absence of remedial action or any demolition or renovation activities at the site. Potential risks identified in the preliminary risk assessment will be investigated more completely during the RI risk assessment. The proposed approach and scope of the RI risk assessment is outlined in Section 3.2.

3.1 PRELIMINARY RISK ASSESSMENT

As described in earlier sections of this work plan, past production operations have resulted in metal and explosives contamination in the Hanley Area of SLOP. During surveys conducted in 1980, heavy metals and explosives were detected on the interior surfaces of buildings and magazines in this area. Lead and chromium were the metals detected at the highest concentrations, with lower concentrations of nickel, cadmium, mercury and silver also detected. Tetryl, HMX, and PETN were the explosives present on building and magazine surfaces above detectable levels.[1] Water samples from sewers which drain the buildings, magazines, and powder wells of the area also contained lead and nickel, indicating some transport of chemicals from the source areas. Tetryl, detected in a single powder well, was the only explosive detected outside of the buildings. Asbestos containing material is believed to exist in the underground tunnel system (as insulating material around pipes) and possibly in and around building spaces (e.g., wall siding).

The extent of contamination at the site is not known. It is possible that soils of the Hanley Area are contaminated with metals and explosives, since dust or water from swept or washed building floors could have been discharged directly to outside soils in the past. (Recent clearing and regrading activities at the site and possible top dressing with fill may have disturbed any existing surface soil contamination.) Off-site soil contamination resulting from surface runoff to areas adjacent to the site is not expected to be significant since drains and sewers of the area likely collect much of the runoff before it leaves the site. It is possible, however, that some soil contamination may exist in adjacent areas if past operations resulted in air emissions and subsequent deposition in these areas. On-site or off-site transport of chemicals in air is not considered likely under current conditions because most of the area is paved and covered by buildings or is vegetated or is currently being reseeded (thereby limiting

---

[1] The concentrations of the explosives on interior surfaces are not known since a spot spray technique was used. The spot spray technique only indicates the <u>presence</u> or <u>absence</u> of a chemical above a certain level (4 ug/m^2 for all explosives, in this case).

wind erosional effects) and because most of the chemicals have low volatility. The extent of contamination in the sewer system and its discharge point is not known, although as mentioned above, metals were detected in the sewer system of the Hanley Area. Off-site contamination resulting from the discharge or overflow from the sewer system is therefore possible. Chemicals from the site also could discharge to groundwater as a result of infiltration from contaminated sewers, powder wells, or surface soils.

The Hanley Area is not currently used and is fenced with barbed wire to prevent public access. Therefore no <u>on-site</u> human exposures are expected to occur. However, it is possible that persons could gain access to the site through unsecured underground tunnels. These tunnels are expected to be closed off in the future, thereby preventing underground access to the site and possible on-site exposures. Because significant off-site transport of chemicals in soil or air is not expected, no off-site exposures to chemicals in these media are expected to occur, including no expected exposures in the Job Corps Training Center located immediately west and adjacent to the site. The potential for off-site exposure to chemicals in surface water or groundwater is not known and cannot be inferred based on the currently available data.

Human exposures could occur, however, if the Hanley Area was reopened and the buildings were used. The primary exposure pathway under this scenario would be direct contact with contaminated building surfaces and/or surface soil (if chemicals are present in the soil). Inhalation of dust generated inside the buildings is possible, but the exposure levels are expected to be much less than those associated with direct contact. No contact with any chemicals present in the sewers or powder wells would be expected to occur.

The magnitude of exposure would depend somewhat upon the uses of the buildings, but no activities are anticipated to result in extensive or frequent contact with building surfaces (e.g., walls, floors, drains, window sills, etc.). Direct contact with building surfaces could result in incidental ingestion and/or dermal absorption of chemicals. Incidental ingestion results from contact of the contaminated skin (for example on the hands) with the mouth during activities such as eating or smoking. Dermal absorption results when chemicals in contact with the skin penetrate through the skin and enter the blood stream. Generally, the dermal absorption pathway is important only for organic chemicals, which are able to penetrate skin; dermal absorption of metals is considered negligible.

To provide a preliminary indication of the potential risks associated with direct contact with chemicals in the buildings of the Hanley Area, potential exposures to some chemicals can be quantified using data collected during the 1980 sampling activities (as reported in USATHAMA 1981). A quantitative evaluation of exposure to the organic chemicals (explosives) detected at the site is not possible because, as discussed previously, the concentrations of the explosives in the interior surfaces of the buildings are not known. Quantitative data are available for inorganic chemicals. Of the inorganic chemicals detected, lead was present at the highest concentrations and also is the most toxic of the inorganic chemicals detected. Therefore, based on the available data, risks associated with exposure to lead will be greater than those associated with exposures to other inorganic chemicals detected at the site and can be used to provide a preliminary upperbound estimate of risks associated with direct contact with building surfaces.

Lead was detected on the building surfaces in the Hanley Area at an average concentration of 6 mg/m^2 and at a maximum concentration of 27 mg/m^2; the average and maximum concentrations in the three buildings proposed by the Army for immediate use[2] as warehouses (buildings 219A, 219D, and 219G) were 1.4 mg/m^2 and 1.9 mg/m^2, respectively (USATHAMA 1981). Risks associated with direct contact of lead at the maximum and average detected concentrations across the site are calculated to provide a range of possible risks at the site; risks associated with direct contact at the average and maximum concentration in the three buildings proposed for use as warehouses are calculated to provide an indication of potential risks associated with use of these buildings before remedial activities have been concluded.

To calculate potential worker exposures to these lead concentrations, it is assumed that a 70 kg (154 lb) worker does not wear gloves and could contact a contaminated surface once a week, 50 weeks each year, for a total of 50 exposure events each year. The area of contact is assumed to be 0.05 m^2, which is the median surface area of one side of a man's hands (calculated from EPA 1985). It also is assumed that 1) with each contact, the chemical present on the surface is completely removed from the surface to the person's hand, 2) a person contacts a different contaminated surface area each time (but with the same lead concentration), and 3) that all lead on the surface of the hand is incidentally ingested.

Using these assumptions, daily human intakes are calculated for the maximum and average lead concentrations in all buildings across the Hanley Area (27 mg/m^2 and 6 mg/m^2, respectively) and average and maximum lead concentrations in the three buildings of the Hanley Area proposed for use as warehouses (1.4 mg/m^2 and 1.9 mg/m^2). The resultant estimates of daily intake are as follows:

- 2.7×10^{-3} mg lead/kg-day (maximum for all buildings in Hanley Area);
- 6.0×10^{-4} mg lead/kg-day (average for all buildings in Hanley Area);
- 1.4×10^{-4} mg lead/kg-day (average for three buildings in Hanley Area proposed for use as warehouses); and
- 1.8×10^{-4} mg lead/kg-day (maximum for three buildings in Hanley Area proposed for use as warehouses).

Risks are estimated by comparing the estimated daily intakes with a toxicity reference dose (RfD). The RfD, expressed in units of mg/kg-day, is an estimate of the daily exposure to the human population (including sensitive subpopulations) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Currently, EPA has not developed an oral RfD for lead. However, for the purposes of this preliminary evaluation,

[2] That is, before the RI is completed.

a provisional RfD of $6.0x10^{-4}$ mg/kg-day is developed based on a previously proposed health-based drinking water standard (see Appendix).

If the estimated daily intake exceeds the RfD (i.e., if the ratio is greater than 1), then exposures may be associated with health risks (although absolute conclusions cannot be drawn, given the uncertainties associated with the RfD and the exposure estimates). The ratios of estimated intake to RfD for exposure to lead on the building surfaces are as follows:

- greater than 1 for the maximum exposure across the Hanley Area;

- equal to 1 for the average exposure across the Hanley Area;

- less than 1 (0.2) for the average exposure across the three buildings proposed for use as warehouses; and

- less than 1 (0.6) for the maximum exposure in the three buildings proposed for use as warehouses.

Thus, potential exposures to the maximum lead concentration in the Hanley Area buildings may be associated with adverse health effects, whereas, potential exposures associated with the average and maximum concentrations in the proposed warehouses may not be associated with adverse health effects. Exposures to the average lead concentration across the Hanley Area is associated with an intake: RfD ratio equal to 1, suggesting that average exposures may not be associated with adverse health effects. However, exposures to the other chemicals present at the site would add to total exposure, potentially resulting in greater risks under the average case and the two maximum cases evaluated.

All estimates of risks presented above should be regarded as preliminary given the limited sampling data upon which they are based. More data are needed on the distribution and extent of chemical contamination in the buildings in the Hanley Area.

No potential impacts on environmental receptors are expected to be associated with the contamination in the Hanley Area, primarily because this area has very limited value as wildlife habitat (e.g., paved areas, buildings) and is likely to support few species. Some wildlife (primarily birds such as robins, pigeons, mourning doves, that are common to urban areas) may use the site occasionally but are unlikely to be significantly exposed to chemicals present inside the buildings, although some minimal and infrequent exposure could be possible. No pathways exist by which wildlife could be exposed to chemicals in the sewers or powder wells. Off-site exposure of wildlife to chemicals that have been discharged from the sewer system to surface water, sediment, or soil is possible but cannot be evaluated currently since no data are available.

3.2 PROPOSED APPROACH AND SCOPE OF RISK ASSESSMENT TO BE CONDUCTED ON THE RI DATA

A human health risk assessment will be conducted to determine the extent to which contaminants present at the Hanley Area of SLOP may pose risks to public health. No environmental assessment will be conducted because, as discussed previously, few wildlife are expected to use the area due to its limited habitat value. The quantitative human health assessment will evaluate conditions at the site in the absence of any remedial actions as well as in the absence of any demolition or renovation activities necessary before the land is excessed. The baseline risk assessment will be based primarily on the environmental monitoring data collected during RI field activities.

The risk assessment will be performed in accordance with EPA policy and guidance on risk assessment (EPA 1986a,b,c,d). The risk assessment will consist of the following four principal steps: 1) identification of chemicals of potential concern; 2) exposure assessment; 3) toxicity assessment; and 4) risk characterization. The components of each of these steps are discussed below, and where appropriate, the anticipated scope of each step will be defined.

3.2.1 Identification of Chemicals of Potential Concern

The first step of the risk assessment is to review the results of available environmental sampling, as well as other site-specific information, to identify chemicals of potential concern for detailed study in the risk assessment. Factors considered in selecting a chemical of potential concern include the chemical's relatedness to past activities at the site or to the suspected source, and the relationship of the sample chemical concentration to the background levels of the chemical. Only chemicals believed to be site-related will be considered for further evaluation. Some constituents will be evaluated by the presence of other constituents (i.e., mixers and powders will be evaluated by analyzing for indicator chemicals of these compounds, such as lead, aluminum, barium and magnesium). Based on the currently available monitoring data, chemicals of potential concern are likely to include: lead, nickel, cadmium, chromium, silver, mercury, HMX, tetryl, and PETN. Other explosives known to be used or manufactured at the site, and therefore potentially present at the site, include RDX, 2,4,6-TNT, nitroglycerine, nitrocellulose, lead styphanate, tetrazene, and 2,4,6-trinitroresorcinol. Asbestos also may be present in some of the buildings and tunnels at the site. Additional chemicals of potential concern may be identified as a result of RI sampling.

3.2.2 Human Exposure Assessment

Exposure assessment is a process which identifies actual or potential routes of exposure and characterizes the likely magnitude of exposure. Population activity patterns on and near the site and information on chemical source, release, and transport are considered when identifying potential exposure pathways.

Exposures may occur through several pathways and are characterized by constructing exposure scenarios. Each exposure scenario defines the source of contamination, possible receptor populations (e.g., workers), and the likely routes of exposure (ingestion, inhalation, or direct contact). Exposures are quantified for each receptor population by calculating chronic daily intakes (CDIs) for each chemical based on the frequency and duration of exposure and the rate of media intake (e.g., amount of water ingested or air breathed each day).

For this risk assessment, the pathways selected for quantitative evaluation will be determined considering the intended purpose of the RI and the proposed scope of the project sampling activities. Since the primary focus of the RI investigation will be to determine potential hazards associated with commercial/industrial re-use of the Hanley Area including the buildings, the pathways selected for quantitative evaluation will be those associated with this use. (This evaluation will not consider any risks associated with renovation or demolition activities required to excess the land.) As discussed in Section 6.4.1, the primary exposure pathways associated with re-use is direct contact by workers with building surfaces and surface soil. Other potential pathways include inhalation of chemicals on dust (and possibly inhalation of asbestos fibers) present inside the buildings and direct contact with water and/or sediment inside the tunnels (if these are anticipated to be used in the future). These latter pathways will be evaluated qualitatively since the RI sampling plan is not designed to completely characterize the indoor-air environment and since frequent use of the underground tunnels is unlikely.

Any groundwater data collected as part of the RI will be regarded as providing preliminary information on potential groundwater contamination. Therefore no quantitative evaluation of exposure will be conducted. The data will be evaluated by comparing chemical concentrations to applicable or relevant and appropriate drinking water standards or other health-based concentration limits (see Section 3.2.4 below).

3.2.3 Human Toxicity Assessment

In this step, chemicals of potential concern will be characterized with respect to their toxic effects in humans and critical toxicity values will be identified for each chemical of potential concern. Two types of critical toxicity values will be identified and used in the human health risk assessment: carcinogenic potency factors (for potentially carcinogenic chemicals) and reference doses (for chemicals exhibiting noncarcinogenic effects). Generally, critical toxicity values developed by EPA are used in the risk assessment. In the absence of EPA values, critical toxicity values will be calculated from the available toxicological literature, if possible.

3.2.4 Human Risk Characterization

As one measure of risk, concentrations of site-related chemicals in environmental media at exposure points will be compared with applicable or relevant and appropriate requirements (ARARs) or other guidance values. Potential ARARs for groundwater include state and federal drinking water standards.

As another measure of risk, a quantitative risk assessment also will be conducted. Quantitative risk estimates are developed by combining the estimated chronic daily intakes (CDI) for potentially exposed populations with

As another measure of risk, a quantitative risk assessment also will be conducted. Quantitative risk estimates are developed by combining the estimated chronic daily intakes (CDI) for potentially exposed populations with critical toxicity criteria. For potential carcinogens, excess lifetime cancer risks are obtained by multiplying the CDI for the chemical of potential concern by its carcinogenic potency factor. Additivity of carcinogenic effects is assumed and the individual cancer risks for all chemicals are summed to derive an overall estimate of excess lifetime cancer risk. Potential risks are presented for noncarcinogens as the ratio of the CDI to the reference dose. Additivity of noncarcinogenic effects also is assumed and the sum of all of the ratios of chemicals under consideration is called the hazard index. The hazard index is useful as a reference point for gauging the potential effects of environmental exposures to complex mixtures.

Quantitative risk characterizations are conducted separately for each exposure pathway and for each source, when appropriate. Qualitative risk characterizations also will be conducted for some pathways at the site. The risk assessment for each exposure pathway includes a discussion of the uncertainties in the estimates.

The results of the risk assessment will provide information useful in determining which areas of the site (if any) need to be remediated before the land can be excessed.

3.3 REFERENCES

Environmental Protection Agency (EPA). 1985. Development of Statistical Distributions or Ranges of Standard Factors Used in Exposure Assessment. OHEA, Washington, D.C.

Environmental Protection Agency (EPA). 1986a. Guidelines for estimating exposures. Federal Register. 51:34042-34054

Environmental Protection Agency (EPA). 1986b. Guidelines for carcinogen risk assessment. Federal Register. 51:33992-34003

Environmental Protection Agency (EPA). 1986c. Guidelines for assessing chemical mixtures. Federal Register. 51:34014-34025

Environmental Protection Agency (EPA). 1986d. Superfund Public Health Evaluation Manual. Office of Emergency and Remedial Response. Washington, D.C. October 1986. EPA 540/1-86/060

U.S. Army Toxic and Hazardous Materials Agency (USATHAMA). 1981. Survey of Hazardous/Chemical Area No. 2 of the Former St. Louis Ordnance Plant. Volume I. Final Report. USATHAMA, Aberdeen Proving Ground, Maryland

ATTACHMENT A

TOXICITY OF LEAD

Absorption of lead from the gastrointestinal tract of adult humans is estimated to range from 8 to 45 percent. In children, absorption from non-paint sources ranges from 30 percent to 50 percent (Hammond 1982, EPA 1986). Other interpretations of the data (Duggan 1983) suggest that non-paint lead absorption may be as high as 70 percent. For adult humans, the deposition rate of particulate airborne lead is 30 percent to 50 percent, and essentially all of the lead deposited is absorbed. Lead is stored in the body in bone, kidney, and liver (EPA 1984). The major adverse health effects in humans caused by lead include alterations in the hematopoietic and nervous systems. The toxic effects are generally related to the concentration of this metal in blood. Blood concentration levels of over 80 ug/dl in children and over 100 ug/dl in sensitive adults can cause severe, irreversible brain damage, encephalopathy, and possible death. The Centers for Disease Control (CDC 1985) have used the value of 25 ug/dl as an acceptable level of blood lead. Recent information, however (EPA 1988a), indicates that physiological and/or biochemical effects can occur at even lower levels. These include enzyme inhibition (16 ug/dL), elevated erythrocyte protoporphyrin (15 ug/dL), interference with Vitamin D metabolism, cognitive dysfunction in infants (10 to 15 ug/dL), electrophysiological dysfunction (6 ug/dL), and reduced childhood growth (4 ug/dL). Decreased fertility, fetotoxic effects, and skeletal malformations have been observed in experimental animals exposed to lead (EPA 1984).

Oral ingestion of certain lead salts (lead acetate, lead phosphate, lead subacetate) has been associated in experimental animals with increased renal tumors. Doses of lead that induced kidney tumors were high and were beyond the lethal dose in humans (EPA 1985). EPA classified certain lead salts in Group B2--Probable Human Carcinogen (EPA 1985), although no cancer potency factor has been established (EPA 1988b). EPA (1988a) has recently proposed a maximum contaminant level goal (MCLG) of zero for lead and considers it inappropriate to develop a reference dose for inorganic lead and lead compounds since many of the health effects associated with lead intake may occur essentially without a threshold. For purposes of this preliminary assessment, a provisional oral RfD of 6.0×10^{-4} mg/kg-day has been calculated from the previously proposed MCLG of 0.02 mg/liter, assuming consumption of 2 liters of water per day by a 70 kg individual for a lifetime. This value is used to assess oral exposures for the purposes of this preliminary assessment only and should not be construed to represent a verified RfD which has undergone EPA peer-review.

REFERENCES FOR ATTACHMENT A

Centers for Disease Control (CDC). 1985. Preventing Lead Poisoning in Young Children. U.S. Department of Health and Human Services. Atlanta, GA.

Duggan, M.J. 1983. The uptake and excretion of lead by young children. Arch. Env. Health. 38147:246-247.

Environmental Protection Agency (EPA). 1984. Health Effects Assessment for Lead. Environmental Criteria and Assessment Office, Cincinnati, Ohio. EPA/540/1-86-055.

Environmental Protection Agency (EPA). 1985. National primary drinking water regulations; synthetic organic chemicals, inorganic chemicals and microorganisms; proposed rule. 40 CFR Part 141. Fed. Reg. 50:46967-47025 (November 13, 198?).

Environmental Protection Agency (EPA). 1986. Air Quality Criteria for Lead. ECAO, Research Triangle Park, NC. EPA 600/8-83-0/8F.

Environmental Protection Agency (EPA). 1988a. Drinking Water Regulations; Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper; Proposed Rule. Federal Register 53:31517-31577.

Environmental Protection Agency (EPA). 1988b. Integrated Risk Information System (IRIS). Environmental Criteria and Assessment Office, Cincinnati, Ohio.

Hammond, P.B. 1982. Metabolism of lead. In Chisolm, J.J. and O'Hara, D.M. eds. Lead absorption in children. Urban and Schwartzenberg, Baltimore, MD. pp. 11-20.